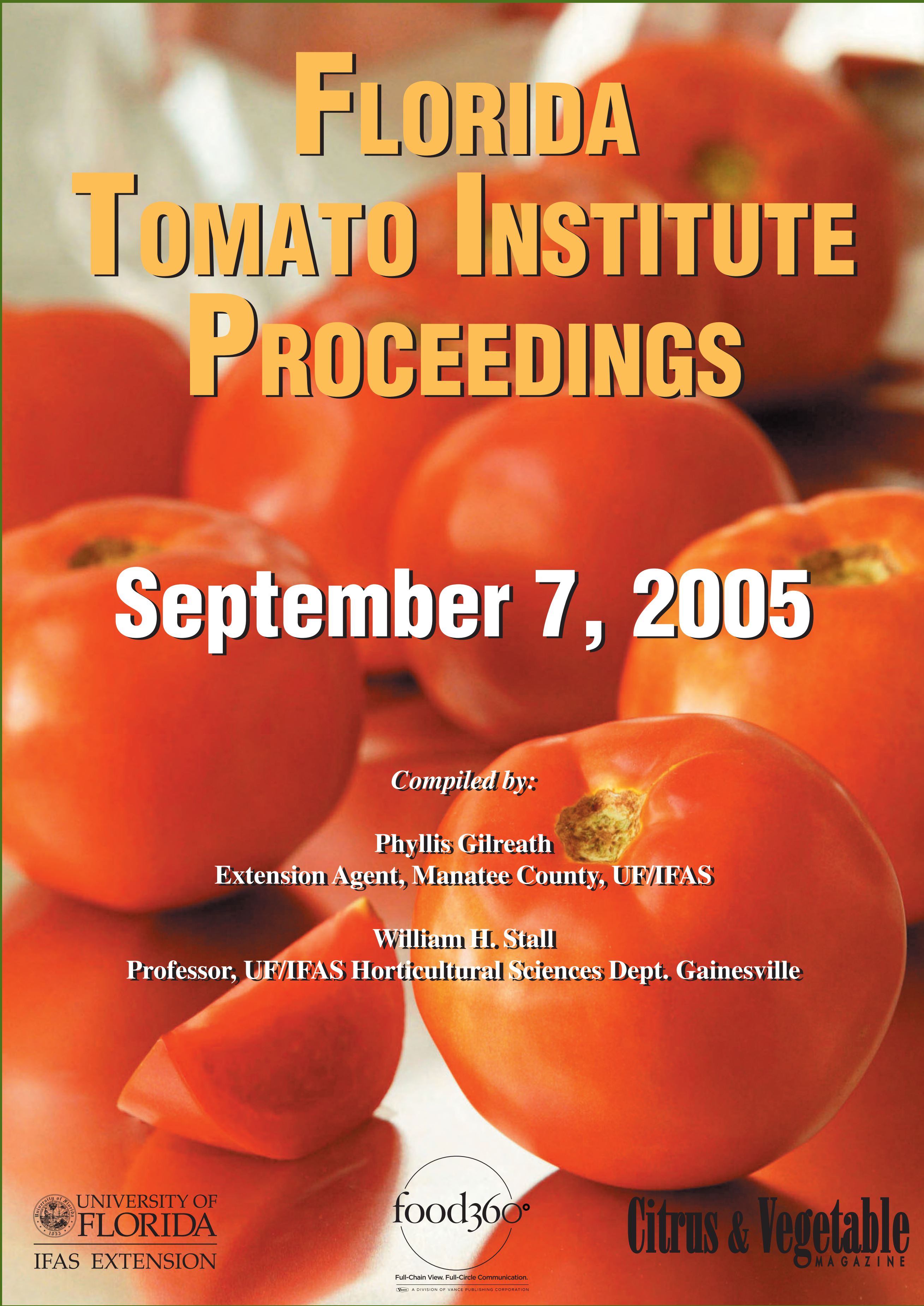

Florida Tomato Institute Proceedings

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2 0 0 5 F L O R I D A T O M A T O I N S T I T U T E

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Morning Moderator: *Kent Cushman, SWFREC, Immokalee*

Afternoon Moderator: *Phyllis Gilreath, Manatee County Extension Service, Palmetto*

CONTROL GUIDES

Hurricane-damaged Tomato Plants

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Some 15 days after transplant, tomato seedlings at a commercial farm near Immokalee, Fla. suffered the effects of hurricane Frances on 5 Sept. 2005. Though many producers were forced to reapply plastic mulch and replant their fields after each of the major storms of the season, Charley, Frances, Ivan, and Jeanne (McElroy, 2004), some growers were able to nurse their damaged plantings back to health. This report documents injury, growth, and yield of hurricane-damaged tomato plants under large-scale commercial conditions in southwest Florida.

Frances caused by far the greatest damage to plants discussed in this report because of sustained high winds in the Immokalee area (Fig. 1). Winds from Frances reached 80 mph, similar to Charley and Jeanne, but winds from Frances were more persistent than that of the other storms. Plants that survived were rated 24 Sept. and labeled for further observation according to arbitrary categories of size and apparent vigor: best, good, fair, and poor (Fig. 2). Plants rated poor, which were small and stunted, were not included in this study because they were not expected to survive or produce marketable fruit. Ten plants of each category were removed from beds by hand with roots intact to record injury and root and shoot dry mass. In addition, ten other plants of each category were labeled in the field for future observations of injury recovery, yield, and final shoot and root dry weight.

Plants exposed to hurricane winds exhibited varying amounts of damage depending on their general and specific location on the farm. Plants were severely damaged in areas located near cypress hammocks, on the leeward side where winds apparently tumbled downward and violently after passing over the treetops. In other areas of the farm, plants were not as seriously damaged but the damage they sustained varied from plant to plant without any obvious pattern. Plants rated best were located randomly next to plants of all other categories: best, good, fair, or poor. It was clear, however, that when damage occurred, injury was located on a section of stem just below the soil line and appeared to be the result of plants being whipped around in the planting hole by strong winds (Fig. 3). Injury was minor on plants rated best, with callous forming around relatively small areas of wounding and only a few roots forming above the injured areas (Fig. 4a and b). In contrast, injury was relatively severe on plants rated fair, with callous forming around wounded areas and, in addition, loss of stem tissue and many roots forming above the injured areas in response to damage sustained by these plants (Fig. 4c and d).

Plants injured by Frances and rated best produced significantly more early yield and larger fruit at first harvest than plants rated good or fair (Table 1). At second harvest, however, plants rated good produced more extra-large sized fruit than plants rated best. Total yields for the second harvest were not significantly different among any of the treatments. Plants rated best and sampled 34 days after transplant (19 days after Frances) exhibited significantly more shoot and root dry mass than plants rated good or fair, but as with yield data, these differences disappeared later when plant shoot and root dry mass was recorded at the end of the study (data not shown). In addition, plants harvested at the end of the study showed stems with varying amounts of internal stem discoloration. (Fig. 5b and d) There was a tendency among plants rated best to have less internal discoloration than plants rated fair, but there was too much variation among best, good, and fair to draw firm conclusions. By the end of the study, sections of stem below the original injury on some plants appeared to have rotted and decomposed. These plants appeared to have lost their original roots, roots that were intact at transplant and soon thereafter, and these plants were relying later in the growing season solely on roots that had developed above the injury (Fig. 5a and c).

Upon reflection, it was a wise decision by the production manager of this farm to nurse hurricane-damaged plants back to health rather than replant the field. Early yield from these plants occurred during a time when market prices were high, about $30 per 25-lb box of green mature extra-large fruit for the first harvest and $40 per box for the second (Fig. 6). These prices would not have been captured if the field had been replanted. Prices at the time of the third harvest were still high but declining rapidly. Commercial harvest of the field precluded recording data from the third harvest.

It was observed that the farm's normal water, fertilizer, and pest control programs were adjusted in response to the needs of the damaged crop. First, moisture content of plant beds was increased to ensure that roots arising from above the damaged areas of plant stems, located at or near the surface of the plant bed, would not dry out. Second, a complete nutrient mix was applied via drip irrigation because it was assumed that plants with damaged stems and roots could not easily acquire nutrients already present in the plant bed. Third, the farm's pest control program was adjusted to minimize further damage caused by opportunistic pathogens invading fresh wounds and weakened plants.

The rating system used in this research—best, good, and fair—was an arbitrary rating system based on obvious differences among individual plants at the beginning of the study. In addition, it cannot be known how damaged plants would perform compared to those not damaged by hurricane-force winds. Despite these limitations, it is clear that the amount of damage sustained by individual plants varied greatly according to location—general location on farm and specific plant-to-plant location. Plants rated best produced higher early yields than plants rated fair. Yields of plants rated good and fair appeared to recover, but yields appeared delayed compared to that of plants rated best.

In conclusion, tomato plants can sustain a surprising amount of wind injury and still recover (Cleugh et al., 1998; Greig et al., 1974; Precheur et al., 1978), producing high yields when growing conditions are carefully managed. Damage to plants was highly localized in an area of stem tissue just below the soil surface. As injury increased, early yields decreased. Early yield of extra-large sized fruit was especially sensitive to the amount of injury sustained. After the third harvest, all plants appeared to recover and significant differences in shoot or root growth were not detected among plants rated best, good, or fair. Finally, plants described in this report were mostly affected by hurricane Frances. Plants on the same farm and located less than a mile away were affected to a greater extent by Jeanne. Winds of this storm not only caused the kind of injury reported here but also a more severe breaking and kinking of stems (Fig. 7).

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Table 1. Yield of first and second harvests of hurricane-damaged tomato plants from a commercial field. Hurricane Frances occurred 15 days after transplant. First and second harvests occurred 79 and 93 days, respectively, after transplant.

Apparent plant vigor [z]	Medium (oz/plant)	Large (oz/plant)	X-large (oz/plant)	Total (oz/plant)	Cull (no./plant)	Fruit wt. (oz)
			First harvest			
Best	2 ab [y]	7 a	64 a	73 a	10 a	8.4 a
Good	1 b	8 a	33 b	42 b	7 a	8.3 a
Fair	4 a	8 a	11 c	22 b	3 a	6.4 b
			Second harvest			
Best	5 a	14 a	13 b	32 a	2 a	6.0 a
Good	8 a	21 a	27 a	56 a	3 a	6.5 a
Fair	8 a	20 a	20 ab	48 a	6 a	6.2 a

[z] Plants were visually rated at the beginning of the study and divided into three categories according to apparent growth and vigor: best, good, and fair.

[y] Values in columns followed by different letters are significantly different at $P \leq 0.05$. Values are means of ten replications.

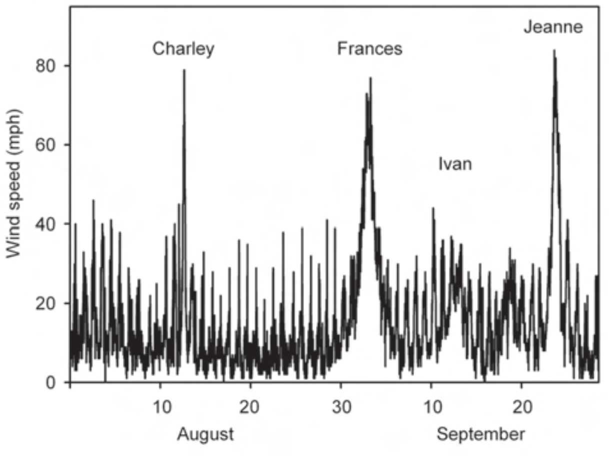

Figure 1. Wind speed at Immokalee, Fla. during August and September 2004 and recorded by an automated weather system (fawn.ifas.ufl.edu) every 15 min at a height of 33 ft. There were four named hurricanes during this period.

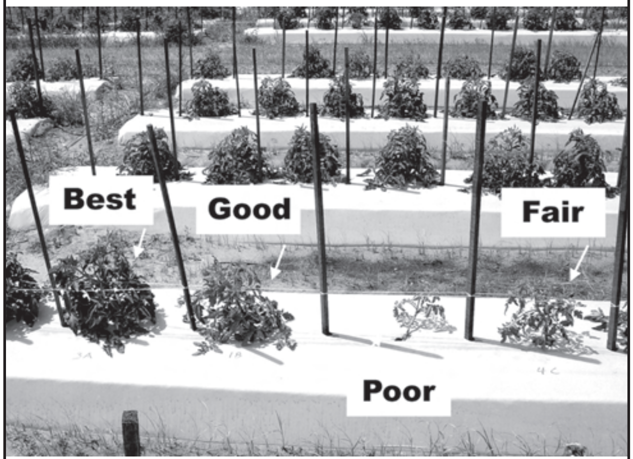

Figure 2. Rating of hurricane-damaged tomato plants according to plant size and apparent severity of injury at the beginning of the study.

Figure 3. Young tomato plant after being whipped around in the planting hole by hurricane force winds.

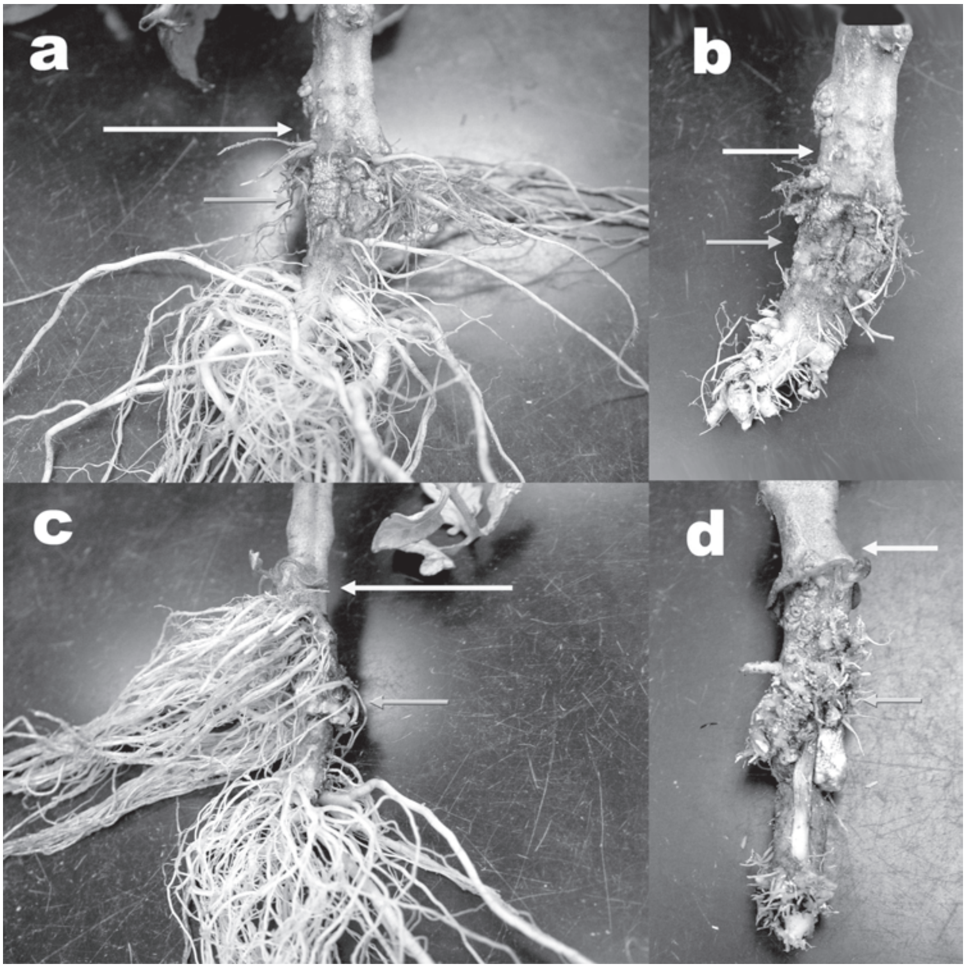

Figure 4. Rooting, stem damage, and callous formation on tomato plants rated best and fair 34 days after transplant and 19 days after hurricane Frances. Shown is plant rated best before (a) and after (b) roots removed and plant rated fair before (c) and after (d) roots removed. Plants rated good (not shown) were intermediate to those rated best and fair. Soil line indicated by white arrow, callous tissue by gray arrow.

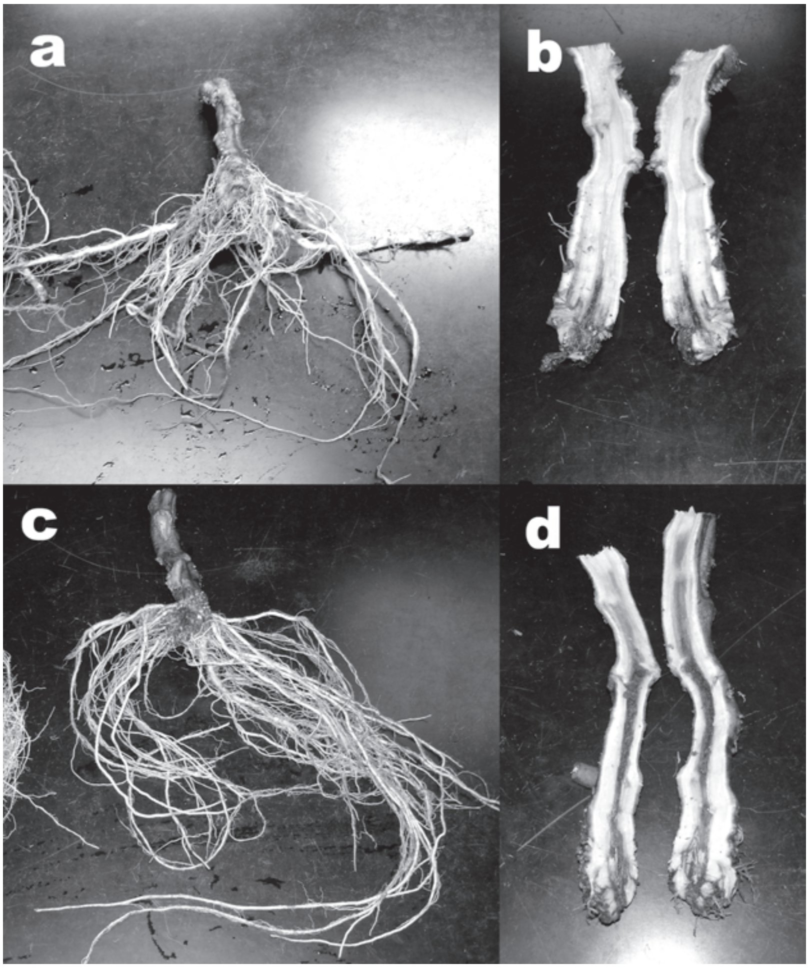

Figure 5. Rooting and stem damage on tomato plants rated best (a and b) and fair (c and d) after third harvest and end of study. Plants rated good (not shown) were intermediate to those rated best and fair. Note discoloration in stems due to original wind injury and apparent infection by soil pathogens (b and d).

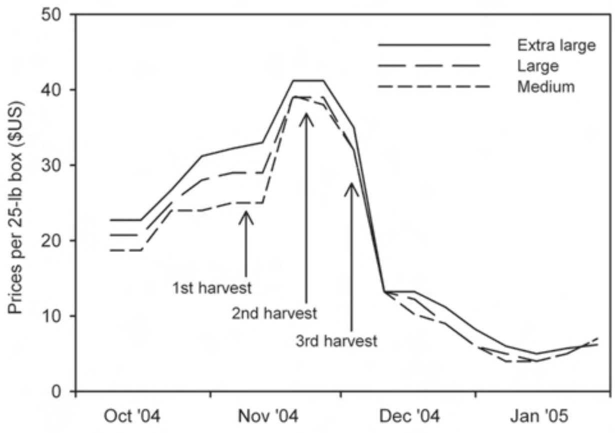

Figure 6. Prices for mature green tomatoes per 25-lb box, US #1 grade, during the period when plants in this study were evaluated and harvested, 2004 to 2005. (Source: F. Roka, personal communication, compiled from USDA/AMS Market News Reports).

Figure 7. Tomato plants on the same farm that escaped injury by hurricane Frances but were later damaged by hurricane Jeanne.

BMP Fertilizer Trials in Central and Southwest Florida.

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ABSTRACT

Southwest Florida is an important production area for winter fresh-market tomatoes with more than 20,000 acres planted annually. The tomato production system in SW Florida (Collier and Hillsborough/Manatee County), which generally includes raised beds, polyethylene mulch and drip irrigation, has been very effective in producing high tomato yields. But, with the development of nutrient best management practices (BMPs) for vegetable crops, N recommendations must be high enough to ensure economical yields, but not excessive to minimize the environmental impact of tomato production. The current UF-IFAS N fertilization rate of 200 lbs/acre of N (with supplemental fertilizer applications under specified conditions) may need to be increased according to tomato growers. Therefore, the objectives of the project were to establish partnerships with selected SW Florida tomato growers to evaluate the effects of N applications in yield, plant growth, petiole N sap, insects and disease incidences. Nine on-farm trials were conducted during 2004 and 2005. Treatments consisted of N fertilizer rates from 200 to 400 lb/acre under seepage and drip irrigation. Nitrogen rates did not affect tomato biomass 30 and 60 days after treatment (DAT), except in the drip trial 60 DAT. Petiole N was higher than the UF-IFAS range in the seepage trials, but not in the drip trial. Yield and financial impacts varied across trials. In all trials except trial six, total production of extra large (5x6) cartons was greater under the higher grower fertilization rate. Total revenue was greater on all experiment sites, even in trial six. Since treatment plots were harvested regardless of market prices, it must be noted that revenue differences for the fall trials were overstated. When prices fall below $5 per carton, growers will choose either to abandon the crop, or direct harvesting crews to pick only the extra large sizes (5x6s). Trial six illustrated an important lesson of market timing. While the 200 lb N/acre rate on trial six produced more total cartons of 5x6s, 5x6 yields from the grower standard plots were greater during the third harvest date, April 19, when the market price exceeded $19 per carton. This project is continuing to study the effects of these treatments over the next two years.

INTRODUCTION

The vegetable production system in Florida, which typically incorporates raised beds, polyethylene mulch, drip or seepage irrigation and an adequate quantity of N-P-K, has been very effective in producing high vegetable yields (Hochmuth et al., 1998). But, nitrogen (N) fertilizer management has become an issue of environmental concern for Florida vegetable growers under the adoption by the State of vegetables BMPs (Best Management Practices). The BMP manual for vegetables endorses UF-IFAS recommendations of 200 lb/acre of N in tomatoes (Lycopersicon esculentum Mill.) (plus provisions for supplemental fertilizer applications), K_2O rates of 225 lb/acre for soils 'very low' in Mehlich 1 potassium, and rates of P_2O_5 ranging from 0 to 150 lb/acre for soils testing very high and very low, respectively (Maynard et al., 2003). In addition to 'basic' fertilizer applications, supplemental fertilizer applications are allowed for tomato in the UF-IFAS recommendations (Simonne and Hochmuth, 2005) and in the BMP manual (Simonne and Hochmuth, 2003) under three situations. When a UF-IFAS irrigation recommendation is followed, supplemental fertilizer applications are allowed (1) after a leaching rain (defined as 3 inches in 3 days or 4 inches in 7 days) for crops (including tomato), (2) under extended harvest season, and (3) plant nutrient levels (leaf or petiole) fall below the sufficiency range. Nutrient management in tomato production is not limited to the total amount of fertilizer found in the recommendation. Together with rate, the effectiveness of nutrient management depends on fertilizer placement, source, growing season, irrigation methods and application time. With drip irrigation, typical fertilization practices consist of applying 25% of the total N and K_2O rates broadcast in the bed, while 100% of P_2O_5 and micronutrients are applied pre-plant. The remaining 75% of both N and K_2O are injected through the drip tape. In some cases, a fertilizer wheel is also used to supply additional fertilizer. For tomato grown with seep irrigation, approximately 25% of the fertilizer is applied broadcast in the bed (bottom or 'cold mix'). The rest of the fertilizer is applied in two bands on the shoulders of the bed ('hot mix'). Water rising by capillarity slowly dissolves the fertilizer band and supplies nutrients to the crop. In some cases, the fertilizer wheel is also used for supplemental fertilization.

Recent unpublished surveys by IFAS personnel indicate that most growers do not follow IFAS nutrient recommendations, particularly for N. Major growers' critique of current IFAS nutrient management includes the lack of large scale on-farm field research in southwest Florida, lack of N recommendation for drip irrigated tomato crops of more than 13 weeks duration, introduction of new varieties that support greater crop yields, and a direct correlation between higher N rates and lower incidence of plant diseases. Many growers believe that UF-IFAS fertilizer recommendations are too low to produce economical yields, especially during wet years. On many operations, N rates are reported to be 150% of the UF- IFAS recommended rate. In some cases, N rates used may be as high as 200% of the UF-IFAS N recommendation. In addition, growers admit they tend to apply irrigation in excess of crop evapotranspiration (ETc), which is the recommended water management practice. Although N runoff has not been identified as a widespread problem in south Florida, the environmental concern remains that the combination of over-fertilization and excessive irrigation may contribute to elevated nutrient concentrations in ground and surface waters.

OBJECTIVES

1) Establish partnerships with selected southwest Florida vegetable growers to evaluate the effects of N nutrient applications under commercial growing conditions.
2) Evaluate the effect of selected N application rates on plant growth, disease incidences, and production;
3) Determine the optimal N rate for tomato production and evaluate the cost effectiveness of selected N application rates;
4) Develop an Extension plan to demonstrate the updated N recommended rate and facilitate the adoption of nutrient BMPs by the industry.

MATERIALS AND METHODS

Ten fertility trials were conducted during the 2004-2005 growing season on farms that not only included 16,000 acres or 80% of staked tomato production in Southwest Florida (Collier and Hillsborough/Manatee County), but also well represented the diversity of growing conditions in the area: six trials were done with seepage and four with drip irrigation. Six trials were conducted in the fall 2004 and four in the spring 2005. Trials also included different varieties (mostly 'Florida 47' and 'Sebring'), plant densities (in-row spacing of 18 to 24 inch/plant; 5 or 6 ft bed centers), soil type (Immokalee and Myakka fine sand), and farm size (100 to 5,000 acres). Treatments consisted of N fertilizer rates ranging from 200 to 418 lb/acre, with each trial including at least the UF-IFAS rate (200 lb N/acre) and the grower's rate (typically higher than the UF-IFAS rate). Plots size varied from 0.1 to 50 acres (Table 1).

Data collection: On 30 and 60 days after transplanting (DAT), the shoots of three tomato plants (fruits removed) selected randomly in each treatment were collected and oven dried at 65^{o}C until constant weight to determine dry matter accumulation (Mills and Jones, 1996). Beginning at first flower buds and continuing until third harvest, fresh petiole sap NO_3-N and K concentrations were measured weekly using ion-specific meters (Cardy, Spectrum Technologies, Inc., Plainfield, IL). Monitoring wells were constructed from a 4-ft long, 4-inch diameter PVC pipe screened at the bottom 8 inch (Smajstrla, 1997). A float was attached to one end of a 0.75-inch PVC pipe to serve as the water level indicator. The float-0.75 inch PVC pipe assembly floated freely inside the 4-inch well. Permanent marks were made at every 1 inch to indicate the water table depth below the plastic mulch bed. Weekly observations of the ground water table depth were taken throughout the growing season. The number of plants showing symptoms of Fusarium crown rot (caused by *Fusarium oxysporum* f.sp. *radicis-lycopersici)* in each harvest plot was counted weekly in trial 1 between 12 Jan. and 2 Feb. Weekly counts of all adult whiteflies *(Bemisia argentifolii)* were made on 10 top fully expanded leaves from 10 randomly selected plants in 3 locations in each plot at four trials (replicates). Analysis of the mean number of whiteflies counted in each plot over each 7-day interval was accumulated to give an estimated value of whiteflies x days for each plot. An analysis of variance (ANOVA) over all replicates (farms) was conducted by considering only the highest and lowest N rate treatments (designated "high" and "low") for those farms where more than 2 rates were tested.

Harvest was done by the project's crew on at least six plots in each treatment following commercial practices. Harvest plots contained 10 plants each, and were 15 to 22 ft long, and were clearly marked to prevent unscheduled harvests by commercial crews. Marketable tomatoes were graded in the field according to USDA specifications of number and weight of extra-large (5x6), large (6x6), and medium (6x7) fruit (USDA, 1997**.** The number of plots harvested in experiment five was twelve. There were no true replications, but within each field the within-plot variability of yield components was compared to the across-plot variability using ANOVA and mean separation using the Duncan's Multiple Range Test at the 5% level. In the Manatee/Hillsborough trial, entire plots (3 rows X 80 ft) were harvested and graded. (Data is not included here due to late harvest but can be obtained from authors.)

The economic section of this paper calculates a monetary value by fertilizer treatment for each farm site. The values compare projected total revenues gained by fertilizer treatment utilizing yield data and market prices reported at the date of each harvest (USDA-AMS, 2005). The purpose of the economic calculations was not to document actual losses or gains, but to illustrate some of the economic issues associated with N fertilization decisions. Southwest Florida tomato growers harvest mature-green tomatoes in two market windows - fall/winter and early spring. It is important to realize that grower prices for the fresh tomato are set on a daily basis and are sensitive to total market supplies. Tomatoes imported from Mexico, Europe and Canada, compete with those from Southwest Florida for the same market windows.

RESULTS AND DISCUSSIONS

Plant growth: There were no differences in plant biomass 30 and 60 DAP for all experiments and seasons, except experiment four 60 DAP (Table 2). For trial four growers N rates produced a higher tomato biomass than 250 lb/acre. Therefore, N rates had little effect on tomato biomass 30 and 60 DAP.

Fresh petiole sap analysis: Changes in petiole sap NO_3-N and K concentrations were different with seepage and drip irrigation, but tended to be above the IFAS sufficiency threshold for all experiments, N treatments and at all stages of plant growth (Figure 1a and b). Measurements of tomato sap NO_3-N and K were higher in the highest N rates than in lower N rates, but higher than their sufficiency range for all stages of plant growth. Measurements of tomato sap K were more stable than sap NO_3-N during the season. In the Hillsborough/Manatee trial, both NO^3-N and K readings were higher than sufficiency thresholds season-long with differences in NO^3-N among treatments only evident just prior to third harvest.

Water tables: The average water table depths among the experiments with seepage irrigation system varied from 18 to 22 in. The maximum fluctuations in the water table depths among treatments within a farm were observed for experiment 1 (Figure 2a) where the water table varied from 11 to 24 in during the fall growing season. For experiments with drip irrigation system the average water table depths varied from 23 to 37 in. The lower water table depth for the drip irrigated farms was expected since irrigation is mainly provided with the drip systems. The fluctuations in water table among the drip irrigated experiments were highest at experiment 4 where the water table varied from 32 in to 11 in. An unusually high water table in late December (Figure 2b) was probably due to a 0.6 in rainfall which occurred on December 25, 2004. Such occasional high water table conditions are mostly unavoidable and are to be expected in Southwest Florida. Overall, the water table depths among different treatments were relatively stable.

Disease incidence: In trial one, the symptoms of Fusarium crown rot first appeared on 12 Jan. 05. The number of plants showing symptoms increased through 2 Feb 05 (Fig. 3). The plants in the plots with the lowest N rate of 200 lb N/acre had the highest amount of disease incidence with an average of 53% symptomatic plants. The other three treatments receiving 236, 260 or 260+ biosolids lb N/acre, had 10%, 27%, and 20% average disease incidence, respectively. These observations support grower's observations and suggest that plant nutritional status may influence the susceptibility of tomato to diseases such as Fusarium crown rot. These results support the need to include the incidence of diseases in the selection of practical fertilizer rates. However, N rate may need to be associated with factors in determining the incidence of Fusarium crown rot symptom because such an association was not observed in all the trials. In the Hillsborough/Manatee trial, the major disease problem was bacterial speck, but, surprisingly, no differences were observed between treatments.

Whitefly counts: More adult-whitefly days were observed on plants receiving the highest N rate as compared to the lowest N rate (Fig. 4). The trend was consistent among all four individual farms (replicates) and statistically significant over all farms $F = 30.6$, $df = 1, 19$, $P < 0.01$. Nitrogen in the form of amino acids is the limiting resource for sternrrhynchous homoptera including whiteflies. Amino acids are concentrated by these phloem feeders through excretion of water and sugars as honey dew. Whitefly adults are known to prefer leaves and plants with higher N concentrations that correspond to higher amino acid titers in the phloem (Bentz et al., 1995). Positive response of adult-whitefly day to N fertilization has also been observed on cotton (*Gossypium hirsutum*) in the field (Bi et al., 2005).

Economic Analysis: Many tomato growers in Southwest Florida believe that they would incur significant financial losses if they limited N fertilization rates to 200 lb N/acre. They believe that a 50 percent increase in the N-rate would support higher production levels and allow them to fully take advantage of favorable market prices. In other words, they view higher N-rates as a form of insurance. Most prices presented in the price history of US#1 tomatoes corresponding to all the harvest dates during the 2004-05 N trials (Table 3) were higher for the larger sizes (5x6s). Under high price market conditions, the price difference between 5x6s and 6x7s increased. When the market prices fell to low levels, there was no price difference between extra large and medium sized tomatoes. Most of the fall trials were harvested during January 2005, a time when the market was at historic low prices. Between the end of December and mid-March, tomato prices were below an estimated break-even price of $9.50 per 25-lb box (UF-FRE, 2003). More importantly, a price of $4 per 25-lb box or below does not even cover harvest, packing, and marketing costs. Consequently, many fields were picked once for the 5x6 size and then abandoned. For the purpose of data collection, grower-cooperators allowed field trials to be picked three times regardless of the commercial market conditions. By the latter part of March, prices rebounded and the market for southwest growers remained strong for the rest of the spring season. Abandoning fields for economical reasons may result in increased residual fertilizer levels left in the field at the end of the season. This may not be an environmental concern for N as it may be denitrified during the summer flooding of the fields (Simonne and Morgan, 2005).

Table 4 summarizes for each trial the impact of N rate differences within a trial on 5x6 yields and total revenue. In trial one, four N-rate treatments were evaluated. On the remaining farm sites, only two N-rates were considered, the "grower-standard" and an IFAS rate of 200 lb N/acre. For example, the "grower-standard" on trial three was 300 lb N/acres, or a difference of 100 lb N/acres between "grower-standard" and IFAS rate. A monetary value of yield differences was calculated on the basis of the projected yield differences between N rate treatments and prices listed in Table 4 that corresponded to the actual harvest dates of a given trial.

Yield and financial impacts varied across trials. In all trials except trial six, total production of extra large (5x6) cartons was greater under the higher grower fertilization rate. Total revenue was greater on all experiment sites, even in trial six. Since treatment plots were harvested regardless of market prices, it must be noted that revenue differences for the fall trials were overstated. When prices fall below $5 per carton, growers will choose to either abandon the crop, or direct harvesting crews to pick only the extra large sizes (5x6s). Trial six illustrated an important lesson of market timing. While the IFAS rate in trial six produced more total cartons of 5x6s, 5x6 yields from the grower standard plots were greater during the third harvest date, April 19, when the market price exceeded $19 per carton.

It is important to emphasize that the yield data presented in this paper are the first of a three-year study. There is ongoing discussion and analysis as to whether or not the yield differences between the fertilization rates are statistically significant. As the data are pooled over several years, statistical differences should become more apparent. Even if the experimental design of this study does not allow for the discernment of statistical differences, a trend has already appeared within the first year data. That is, higher fertilization rates from the various "grower-standard" treatments produce more total revenue. It is a trend that reinforces the economic reasoning behind the observed behavior of tomato growers pushing for higher N fertilization rates.

What cannot be incorporated into this analysis are the environmental risks associated with off-site movement of nutrients such as N. Whether N is an environmental hazard in southwest Florida is a debatable issue. However, regardless of perspective, environmental costs are currently not a part of a grower's decision-making process. If N proves to be a real environmental threat, then public policy, either through regulation or incentive payments, will be needed to force changes in N fertilization rates beyond the direct impact to production.

Extension and Education: Grower's were highly engaged in the project and strong successful partnerships were developed throughout the fall 2004 and spring 2005 growing seasons. Growers provided input in determining fertilizer rates and helped apply the treatments. Weekly visits throughout the growing season by project leaders were organized to discuss progress toward the goals and to review in-season weekly progress reports. These weekly progress reports were farm-by-farm reports of sap petiole analyses, water table depth, dry matter accumulation, and yield. Additionally, growers received a final report at the end of the season.

Educating farm employees on nutrient management issues was also an important part of the project. For example, one employee on three farms was trained in the use of cardy-N and K meters to monitor sap NO_3-N and K plant nutrient management, and to interpret the results. Growers agreed that this tool was a simple, practical way to monitor plant nutritional status.

SUMMARY FOR THE 2004-2005 SEASON:

Results from these first-year trials are encouraging and indicate that this project is on track to achieve its objectives:

1. On farm trials along with extensive one-on-one grower contact was an effective means to engage growers in the implementation and outcome of this research and demonstration project
2. N recommendation for tomato is not a simple "one size fits all". Recommendations should consider irrigation method (seepage or drip irrigation) and growing season (early, mid or late plantings requiring from 15 to 20 weeks from plating to harvest), and position of the bed relative to irrigation (adjacent v-ditches or increasingly further away)
3. In-season tomato nutritional status monitoring provides a real-time tool for assessing plant fertilizer needs
4. For a relatively dry year like the 2004-2005 season, grower's rate resulted in significantly greater early 5x6 yields in 2 out of 7 trials (29% of the cases)
5. Education is needed for drip-irrigation growers and a Drip Irrigation School should be organized in southwest Florida

Outlook for the 2005-2006 Season:

1. All participating growers intend to participate next season
2. Growers want to add early plantings (August) to the current planting window (October-February)
3. Interest in conducting similar trials with grape tomato (a rapidly expanding segment of the tomato industry in south Florida for which no specific fertilizer recommendations exist)
4. Automated soil moisture monitoring equipment will be installed at three seepage-irrigated sites next season
5. Bed position in relation to the v-ditch will be taken into account

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Table 1. Experiment number, irrigation type, N rates evaluated, plot size, planting date, number of harvest in the 2004-2005 N management trials in Southwest Florida.

Trial number	Farm	Season	Irrigation type	N rate (lb/acre)[z]	Plot size (acres)	Planting date	Number of harvest
1	1	Fall, 2004	Seepage	200, 240, 260, 260+BS[y]	0.33	28 Sept.	3
2	2	Fall, 2004	Seepage	195 and 255	0.83	5 Oct.	3
3	3	Fall, 2004	Seepage	200 and 300	0.83	5 Oct.	2
4	4	Fall, 2004	Drip/seepage	250 and 418	0.10	11 Oct.	3
5	5	Spring, 2005	Drip	260 and 300	25	22 Nov.	3
6	2	Spring, 2005	Seepage	195 and 255	0.83	3 Dec.	3
7	2	Spring, 2005	Seepage	195 and 255	0.83	28 Jan.	3
8	6	Spring, 2005	Seepage	200, 250, 300, 350 and 400	0.033	10 March	3

[z] based on 6-ft spacing or 7,260 linear bed feet per acre
[y] BS = biosolids

Table 2. Effect of N rates on plant biomass 30 and 60 days after transplant (DAP) during tomato season 2004-05.

Experiment	N Treatment (lb/acres)	30 DAP	60 DAP
		Plant biomass (g)	
		Fall	
1	200	39.3	201.1
	236	35.5	188.3
	260	39.0	240.7
	260/BS	34.7	201.8
Significance		ns	ns
2	195	28.7	205.7
	255	30.8	172.9
Significance		ns	ns
3	200	47.0	235.7
	300	50.7	261.3
Significance		ns	ns
4	250	30.9	113.5
	418	33.5	186.8
Significance		ns	**
		Spring	
5	200	13.8	151.4
	300	14.1	126.2
Significance		ns	ns
6	195	6.0	147.3
	255	6.0	163.9
Significance		ns	ns
7	195	15.7	130.8
	255	14.6	142.1
Significance		ns	ns

[z] Means in a columns with the same letter are not significantly different by Duncan's Multiple Range Test (P = 0.05)
[y] **, * Significant and [ns] non-significant at P = 0.01, P = 0.05, respectively.
[X] Biosolids = BS, 1000 lb/acre Class A biosolids.

Table 3. Price history for US#1 ($ per 25-lb box) during the harvest window (27 Dec. 2004 to 2 June 2005) of Southwest Florida tomato industry. (Source: USDA, Agr. Mark. Serv., Fruit & Vegetable Market Rept.)

	Grade class		
Harvest Date	5x6 ($/box)	6x6 ($/box)	6x7 ($/box)
27 Dec.	9.20	7.20	7.20
3 Jan.	7.20	5.20	4.20
10 Jan.	5.20	4.20	3.20
18-19 Jan.	4.20	3.20	3.20
27 Jan.	6.20	6.20	6.20
8/10 Feb.	7.20	7.20	7.20
15 Mar.	9.20	9.20	9.20
22 Mar.	13.20	12.20	10.20
29 Mar.	13.20	11.20	9.20
5 Apr.	13.20	10.20	8.20
12 Apr.	13.20	10.20	8.20
19 Apr.	19.20	17.20	13.20
2 May	17.20	15.20	13.20
19 May	13.20	13.20	13.20
2 June	13.20	13.20	13.20

Table 4. Differences between higher and lower nitrogen rate (lb/acre), 5x6 yield (25-lb box/acre), and revenue ($/acre) in seven N fertilization trials conducted in 2004-2005 in Southwest Florida.

Trial		Difference Higher minus Lower N rate		
1 Seepage/Fall 3-harvests	N rate (lb/acre)	36	60	60+BS
	5x6 Yield (boxes/acre)	415	348	98
	Revenue ($/acre)	$2,848	$1,191	$773
2 Seepage/Fall 3-harvests	N rate (lb/acre)		60	
	5x6 Yield (boxes/acres)		171	
	Revenue ($/acre)		$1,042	
3 Seepage/Fall 2-harvests	N rate (lb/acre)		100	
	5x6 Yield (boxes/acre)		17	
	Revenue ($/acre)		$1,064	
4 Drip/Fall 3-harvests	N rate (lb/acres)		168	
	5x6 Yield (boxes/acre)		388	
	Revenue ($/acre)		$3,104	
5 Drip/Spring 3-harvests	N rate (lb/acre)		40	
	5x6 Yield (boxes/acre)		187	
	Revenue ($/acre)		$3,567	
6 Seep/Spring 3-harvests	N rate (lb/acre)		60	
	5x6 Yield (boxes/acre)		-84	
	Revenue ($/acre)		$422	
7 Seep/Spring 3-harvests	N-rate (lb/acre)		60	
	5x6 Yield (boxes/acre)		134	
	Revenue ($/acre)		$2,064	

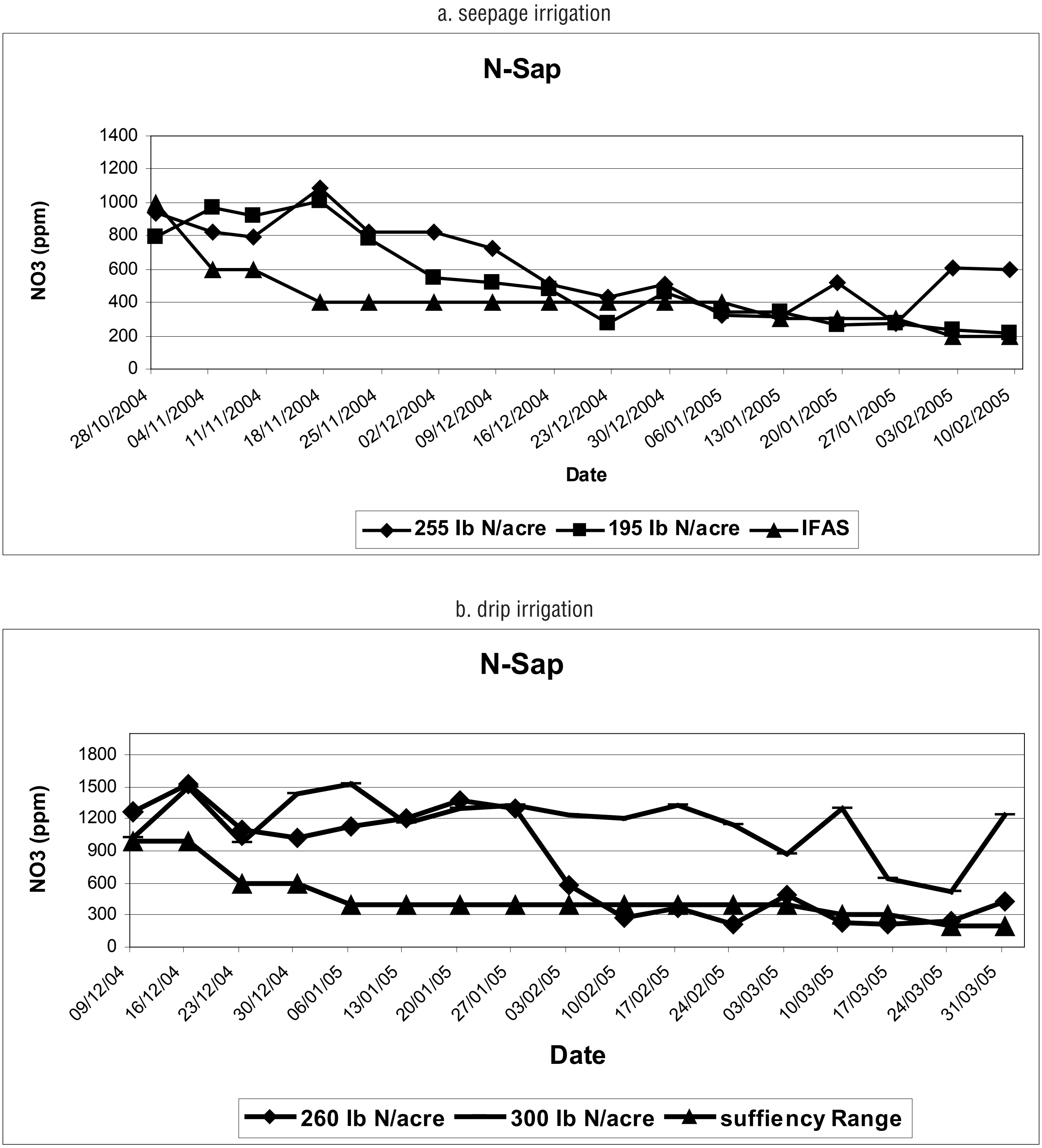
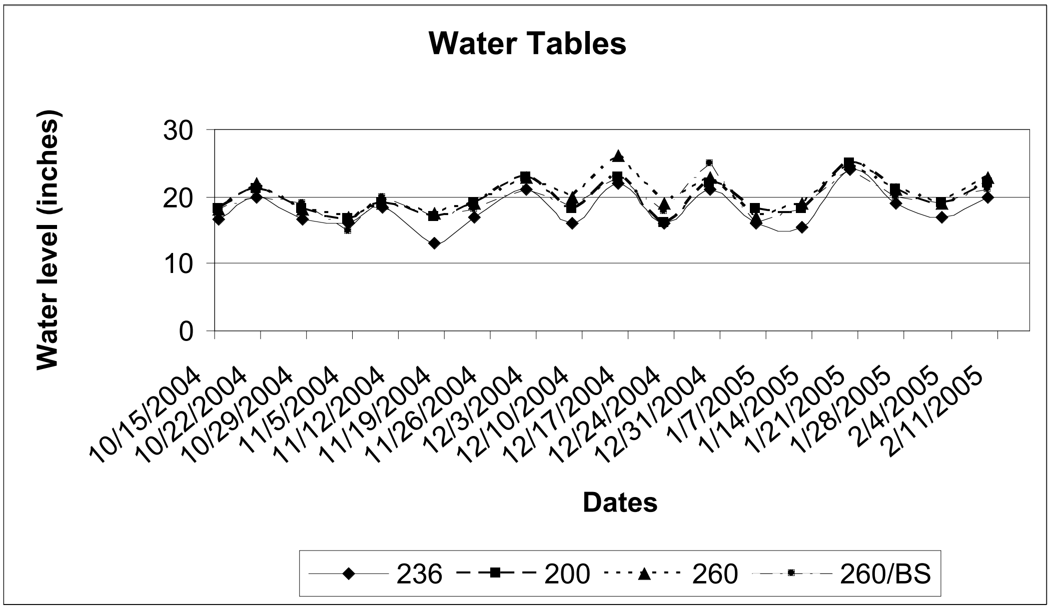
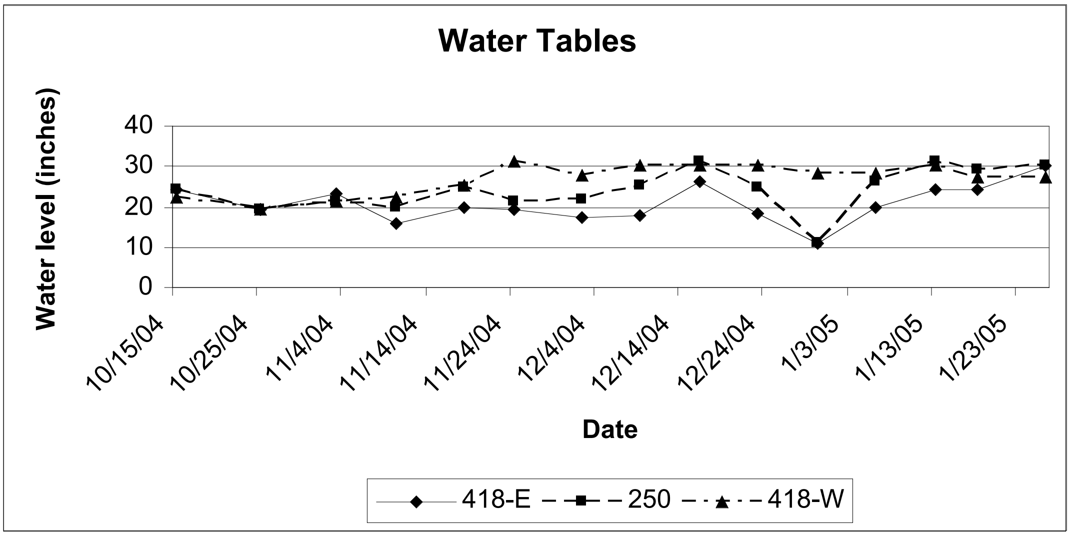


Figure 1. Petiole sap NO3-N concentration for tomato grown with (a) seepage and (b) drip irrigation during the 2004-2005 seasons in Southwest Florida.

a. seepage irrigation



b. drip irrigation



E = East well; W = West well

Figure 2. Water table depth (inch) below the top of tomato beds in fields irrigated with drip (a) and seepage (b) irrigation during the 2004-2005 season in Southwest Florida.

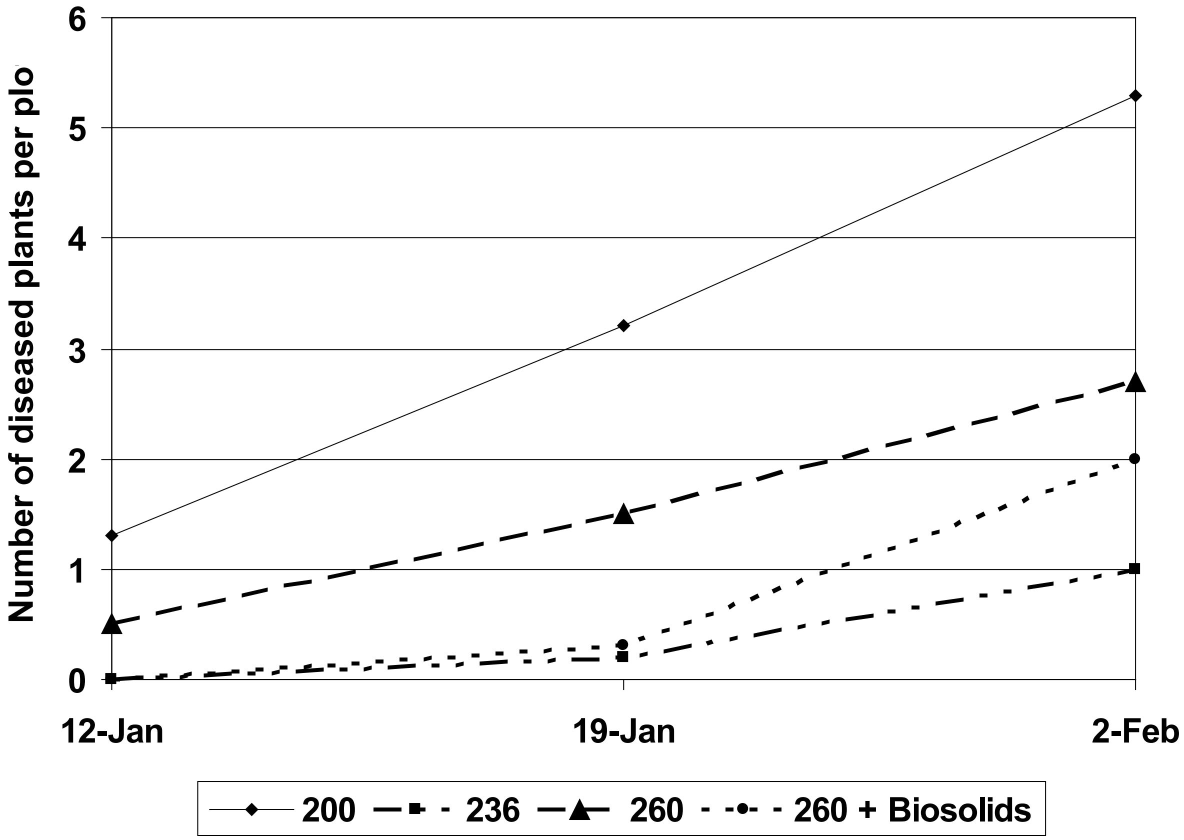


Figure 3. Incidence of Fusarium crown rot (caused by Fusarium oxysporum f.sp. radicis-lycopersici) on tomato plants in trial 1 between 12 Jan. and 2 Feb. 2005 in Southwest Florida. (1 plot= 10 plants).

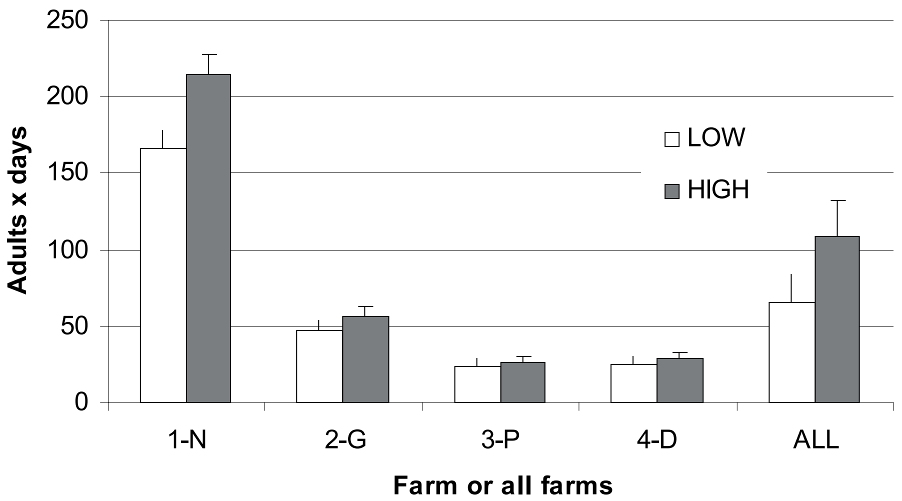


Figure 4. Cumulative mean adult whiteflies x days with standard error bars on 4 farms in southwest Florida, fall/winter 2004-2005.

Can we Rely on SOS when our Plants are in Trouble? (Snake Oil Science)

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Vegetables need water, mineral elements, oxygen, carbon dioxide, light and time to complete their life cycle and produce economical yields. Vegetables also need to be protected from biotic (disease, pests, nematodes, mammals) and abiotic (heat, drought, flood, wind) stresses. Hence, vegetable production requires the use of a wide range of products (also called "production inputs") which include water, fertilizers, fungicides, insecticides, and soil fumigants. The composition of these products is well defined and they have a clear role in vegetable production, as well as a clear mode of action. In contrast, a wide array of production inputs has less defined roles and modes of action. Typically, these production inputs are "stimulators" or "growth enhancers" of some sort (Table 1). These production inputs are affectionately referred to as "snake oils" although "biostimulant" should be used. The objectives of this paper are to (1) highlight the origins of the "snake oils", (2) identify warning signs, (3) provide guidelines for conducting on-farm trials to test efficacy of biostimulants, and (4) provide a brief summary of biostimulant research in Florida.

The term "snake oil" was originally used to describe a type of 19th century patent medicine sold in the United States that claimed to contain snake fat, supposedly an American Native remedy for various ailments. Clark Stansley's snake oil tested by the federal government in 1917 was found to contain mineral oil, 1% fatty oil (presumed from beef), red pepper, turpentine, and camphor. This product did not contain snake parts, but its formulation resembles that of modern-day capsaicin-based liniments. "Snake oil" became rapidly a synonym of "quack" or fraudulent medicine, and was used to describe a worthless preparation fraudulently peddled as a cure for many ills. In this historical context, labeling a product as a "snake oil" implied an intention to deceive. By extension, "snake oil" is used today to describe products that have no clear use or that can be easily replaced in areas as diverse as computer cryptography, medicine, insurance, or engine treatment products. This term has also found its way into the agricultural vocabulary. The conventional wisdom defines "snake oil" as a product that may help crop production. In this paper, the term "snake oil" is used only to describe a class of products, and does not imply any intention by any party involved to engage in a deceptive practice.

While defining biostimulant is difficult, "snake oils" share common characteristics: they seldom hurt plants, they usually don't help, they cost money, and they always make the user feel better. When growers consider using a production input, the two most important points they consider first are price and efficacy. The old motto "you get what you pay for" often helps justify a hefty price and creates the willingness to buy almost any product. Warning signs that a product may be a "snake oil" include (1) sales language that states or implies "Trust us, we know what we are doing", (2) the impossibility to know what is in the product under the pretext of "old proven secret recipe", (3) the abundant use of invented terms (technobabble), obscure jargon, or trademarked terms that confuse rather than explain, (4) claims of "revolutionary breakthrough", or (5) most important, unsubstantiated claims

So if the warning signs are so easily recognizable, how did "snake oils" get associated with agriculture and vegetable production? Some reasons may include (1) the perennial attractiveness of what is "new" and "improved", even at the expense of proven efficiency; (2) failure of proven practices that trigger an immediate and desperate search for alternatives; (3) decision based on emotions rather than on facts; and, (4) the fear of a customer to show ignorance by not understanding an obscure, complex lingo used to describe a product and its benefits. Clearly, the best remedy against disappointment is information and education.

Products that (1) have been tested by not-for-profit organizations such as public universities, (2) have an established mode of action, (3) are efficient over a defined range of circumstances, and (4) are reasonably priced, may not be "snake oils" and may be worth using (Trenholm, 2003). In the absence of reliable information, the best alternative to test a biostimulant's efficacy is to try it under the conditions of its intended use: in the field, with a crop. Field trials should be well defined, large enough, representative, and fair. The purpose of a field trial should be well defined. Doing so will help develop a valid protocol that really puts the product to the test. Moreover, a clear purpose will help assess the mode of action. Trials involving few plants may not reflect field variability, thereby yielding erroneous conclusions. Trials should include areas where products are tested and a control area. Having a control helps isolate the effect of that product alone, since the only difference between the treated area and the control is the application of the product tested. Ideally, trials should replicated. Trials should be conducted in a "real" field, not in an area of the farm where growing conditions are less than optimal. Areas such as row ends, low spots, and shady areas should be avoided. Data collected should be simple, and relevant to the set objectives. Identifying before the trial begins where/how/when the trial will be conducted will help ensure the trial is valid, and the conclusions are reliable. Results of well-conducted on-farm trials will yield trustworthy information about the efficacy, but at times will not reveal the composition - and therefore the mode of action - of the product. As the conventional wisdom admits " if you do not know how a product works, you won't find out why it does not work".

Biostimulant research with vegetables has a long history in Florida (see additional resources section). Most products evaluated were foliar or soil-applied fertilizers. Their intended effect on vegetable crops is typically to promote plant growth of high-value crops such as tomato (*Lycopersicon esculentum*), pepper (*Capsicum annuum*) or strawberry *(Fragaria x Annassassa)*. Collectively, research results can be summarized as inconsistent from year to year, better performance under stressful conditions, and generally too expensive for regular use. In contrast, soil applications of humate-based products did not increase root length of red maple (*Acer rubrum* L.), but they increased sap flow (Kelting et al., 1998). In a pot experiment, green bean (*Phaseolus vulgaris*) mean pod fresh weight responded to algal treatment (Russo and Berlyn,1992). Overall, the literature contains a few isolated reports of positive effects of biostimulants. It is unfortunate that the vast majority of research conducted on biostimulants aims at testing the efficacy of a formulation (sometimes undisclosed). The projects aim at finding out if the product works, or if it does not. In either case, few attempts are made to understand the reasons why the products worked or did not. Hence, current work on biostilmulant is somewhat like short-term product testing. An alternative approach would be to start with a formulation, optimize it, and develop an understanding of the role of each ingredient. Unfortunately, this long-term, costly approach is not commonly used. Until then, we'll have to expect miracles from SOS.

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Table 1. Claimed benefits, composition, and mode of action of selected biostimulantsz

Biostimulant type	Claimed benefit[y]	Composition and/or mode of action[y]	Reference	Comments
Fluid nutrient for leaf application	Polyamines act as growth factors, favoring cellular division at meristems and flower morphogenesis. They regulate ethylene synthesis and plant oxidative processes, delaying senescence	Nitrogenated organic substances, in which polyamines stand out	http://www.bioplanet.it/english/lineaplan/prodotti.php3?p=filloplan	Foliar fertilization with inorganic nutrients is a well documented practice. UF/IFAS recommendations for foliar fertilization support the application of micronutrients, especially on alkaline soils (Simonne and Hochmuth, 2004)
Bee attractants	Increased foraging activity resulting in better fruit set	Honeybee pheromone, Queen mandibular gland pheromone, or synthetic pheromone	Malerbo-Souza et al., 2004 Tew and Ferree, 1998	The need for bees to pollinate vegetables, especially cucurbits, is well documented (Sanford, 1992). Scientific studies have demonstrated the efficacy of bee attractants (Malerbo-Souza et al., 2004; Tew and Ferree, 1998). In commercial fields, bee behavior is affected by many factors including bee attractants.
Organic soil amendment	Promotes beneficials in soil that can prohibit the growth of nematodes. Supplements roots under stress with certain elements	Natural sugars, sugar plant extracts, humectants, surfactants, trichoderma, beneficial microbes, naturally occuring vitamins, amino acids, humic substances, langbeneite, enzymes, beneficial bacteria, sea kelp extract, proprietarian additives	http://www.growthproducts.com/news/pr_essential_natural_biostimulant.cfm	Source of carbon, water, terminal acceptors of electrons are among the compounds needed for microbiological growth. Many of the ingredients found in these formulations are needed for microbe growth. The long-term positive effect of organic matter on soil microorganism populations is well documented.
Liquid organic amendment and biostimulant	Rejuvenates soil structure, stimulates root and plant growth, and provides a food source for microbial activity	7% humic acid, cellulose fiber, kelp extract, mon/disaccharides, lignin and natural	http://www.proganic.com/proganic.com/website/organic_fertilizers_sale.htm	Soil amendments applied at rates in the range of few tons per acre may be more efficient than formulations applied at rates in the range of a few pints per acre.
Soil conditioner and plant biostimulant	Valuable in soil regeneration, restoration, and in bioremediation. Destroys harsh chemicals. Can increase microbial and mycorrhizal activity. Key to healthy plants	Humasol concentrate and kelp	http://www.outsidepride.com/store/catalog/Liquid-Soil-Conditioner-p-17888.html	Modifying soil structure or soil water holding capacity are targeted, possible soil improvement measures. Regeneration and restoration are noble goals that need to be better defined if they are to be reached

[z] Mention of products and web sites are made for illustration and educational purposes only and do not represent a recommendation or endorsement by UF/IFAS of these products over similar ones. Consult EDIS (at www.edis.ifas.ufl.edu) for current UF/IFAS recommendations

[y] Information from the manufacturer's or distributer's web site

Water Infiltration and Postharvest Problems in Tomato Fruit

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Persistent rainfall and generally wet conditions create a high risk for microbial problems in tomato fruit. With high day-time temperatures, wet weather creates an almost explosive situation where growers and handlers cannot successfully get their crop to market because of decay. Anecdotal reports have suggested that water chlorination practices may be adequate or even excessive and still fail to prevent decay if the fields are wet. In contrast, prior to wide spread adoption of water chlorination, packinghouses routinely packed, shipped and marketed tomatoes without incurring major fruit losses, particularly during the drier times of a season. Below, we describe some of the factors that appear to be responsible for decay during wet weather and sometimes in association with mishandled fruit.

Most, if not all, decay outbreaks, where rot incidence exceeds grade standards but wound incidence is below those standards, can be traced back to a water congestion of the fruit surface. Water congestion means that fruit cell sap and water permeate openings (=pores) on the fruit surface. These openings are connected with a system of air spaces (=intercellular spaces) that enable cells inside a fruit to exchange CO_2 for O_2. Sufficient gas exchange to support living cells cannot occur through more than a few mm of cell sap or water (Burton, 1974). The air spaces in all types of fruit, and, indeed, in all types of plant tissues are connected to pores in the plant surface. Certain structures, such as the hydathodes of leaves, are open pores that enable the plant to expel excessive water in the familiar guttation process (Curtis, 1943). Another type, the stomata, are closed in darkness but open in response to light to allow exchange of O_2 for CO_2 in photosynthesis.

Virtually every type of pore on the plant surface can become water congested creating what has been called a water channel that connects the plant's internal environment with that existing externally (Johnson, 1947). Water placed on a water channel frequently moves into the plant tissues, either in response to capillary forces or transpiration (moisture loss by the tissues). The water movement can carry particulates including the carbon particles in India ink and various bacteria including the gram positive cocci of Staphlycoccus aureous, an animal pathogen and gram negative rods such as various plant pathogenic bacteria (Diachun et al., 1944). This movement occurs quite rapidly with rates measured in seconds to minutes (Johnson, 1947).

The pores on a tomato fruit are mostly in the stem scar where most of the gas exchange occurs (Brooks, 1937). The connective or white tissues within the stem scar include cells arranged with a myriad of air spaces and pores. These cells form an abscission layer as the fruit matures. Additionally, a vascular system is present in bundles arranged in a ring around the outside of the stem scar. When a fruit is harvested, the cells on the abscission layer normally separate cleanly, whereas those in the vascular bundles are mechanically separated, meaning torn apart.

A stem scar is not highly permeable to water, particularly when it's dry. However, water can enter these tissues through a purely physical process called infiltration (Bartz and Showalter, 1981). Additionally, water has been observed to enter vascular tissues in the stem scar, perhaps analogous to a flower stem. A water soluble dye flooded into the stem scar of a fruit picked during a rain shower was observed to move in delicate threads (likely xylem vessels) in the walls of the fruit. The torn cells around the vessels in the vascular bundles also appear to be a point of entry for water. Usually, however, direct penetration of the cells in a stem scar does not occur unless the fruit was physically treated to ensure a pressure imbalance between the air within and that outside the fruit. Two different physical phenomena can cause a sufficient pressure imbalance for infiltration. The cooling of a warm tomato that is submerged in water leads to a reduction in air pressure in the fruit's intercellular spaces (Bartz and Showalter, 1981). The resulting partial vacuum can draw water through the stem scar into the fruit. The direct pressure of water on the stem scar surface can also cause an infiltration (Bartz, 1982). This water pressure can result from a hydrostatic force such as with immersion depth or from a direct impact with water such as in dump tanks or where heavy streams of water are applied to unload gondolas.

The infiltration of fruit by water, usually defined as a weight increase ≥ 0.1g, is usually associated with a high risk of postharvest decay. However, the manner by which infiltration occurs and the presence of free chlorine in the water affect that risk. Cooling fruit from 35 to 20°C with an aqueous cell-suspension of soft rot bacteria in a shower hydrocooler at 10°C produced 50 to 100% decay over a 10-day 20°C storage period (Vigneault, et al., 2000). However, when chlorine was added to the suspension before it was used to cool the fruit (50 to 200 mg/L of free chlorine at pH 7.0), the fruit remained free of decay throughout the storage period. By contrast, when tomatoes were infiltrated with cell suspensions plus free chlorine (150 mg/L, pH 6.8) during immersion depth experiments, up to 22% of the fruit developed soft rot during a 12-day storage at 24°C (Bartz, 1988). Thus, infiltration from direct contact with water is a much greater hazard than that associated with temperature change.

Water congestion of the stem scar apparently can occur in the absence of a detectable fruit weight increase. The importance of this to postharvest decay is unknown. Spray inoculation of the freshly exposed stem scar of 320 fruit of eight different breeding lines and cultivars with soft rot bacteria, led to less than 10% decay (adjacent to stem scar) by the time the fruit were table ripe. However, none of the 320 control fruit developed lesions adjacent to the stem scar. Conditions were dry and hot at the time of harvest, which are not conducive to decay.

Several factors affect how much water is absorbed when fruit are submerged in water, cooled in water, dropped into water or struck by a stream of water. Water absorption is greatest in green and least in table ripe fruit. Pinks and breakers fall in between. Fresh stem scars absorb more than those that are 24-hr old. Moreover, as the stem scar dries, water intrusion is less likely to occur. Fruit harvested with stem scars attached decrease in water uptake tendencies at about the same rate as fruit pulled cleanly from the plant. Thus, it appears that residual moisture in the stem scar and not a fresh separation scar is more important to water uptake.

Cultivars exposed to the same immersion depth or temperature differential in water differ in water uptake (Bartz, 1991). The differences tend to be consistent among different fields and planting dates. After harvests of Jay Scott's breeding line test in Bradenton, Spring, 2004, fruit of Florida 91 and 47 absorbed more water than several other entries (Table 1). This difference was consistent over two harvests of the plots. 'Sebring' and 'Soraya' absorbed the least water. In a later planted "soft rot" test, Florida 91 and 47 were again the highest, whereas Sebring was the lowest (Table 2). Here, fruit from one harvest was separated into two groups. One group was tested for water uptake at 4 h after harvest and a second at 24 h after harvest. The rankings were generally similar although Sanibel and Solar Fire were not as receptive to water at 24 h. In a similar "soft rot" test at Quincy, Florida MH-1 ranked the highest whereas Peto 882, a Roma cultivar was the lowest (Table 3). Florida 47 and Florida 91 again ranked high, whereas Sebring and Solar Fire were lower. Fruit from the second harvest absorbed more water than those from the first. Significant rainfall had fallen between the two harvests and we had to dodge water puddles during the second harvest. Two groups of fruit samples were evaluated at the second harvest, one at 5 and the other at 22 h after harvest (Table 4). The relative rankings did not change between the two tests. Finally, this past Spring (2005), Solar Fire was the highest for water uptake, whereas Florida 47 and Florida 91 appeared intermediate (Table 5). Amelia was the lowest. Weather conditions at harvest were dry and hot. There was no standing water.

The level of applied nitrogen significantly affected water uptake for 'Amelia' versus 'Florida 47' in four recent tests (Spring 2004 and Spring 2005) conducted by Drs. George Hochmuth, Jr. and Steve Olson—two at Live Oak and two at Quincy. However, the differences in uptake attributed to cultivar and to time after harvest were much larger than those associated with N level. Plots fertilized with the highest H level, 350 lbs/ac did not produce fruit that absorbed the most water.

In general, fruit size is correlated with tendency to absorb water. Thus, cultivars that produce larger fruit can be expected to absorb more water. This tendency complicates cultivar comparisons. Expressing weight increase as a percentage of fruit weight eliminates some but not all fruit-size bias. However, the critical factor is how much water is absorbed. Fruit aren't likely to decay if they haven't absorbed water.

Warm fruit absorb water more readily than cool fruit (Bartz, 1981). The reason for this is unknown. Warm fruit contain less air than cool fruit because of the difference in gas density. As such, the air in warm fruit may be more easily compressed. However, once water enters the surface of the stem scar it appears to be under capillary forces. Flooding the surface with additional water produces water intrusion likely until the pressure of trapped air is sufficient to counteract the capillarity.

When fruit absorb water during packinghouse handling, microbes on the stem scar are internalized as discussed above. Additionally, the water channels in congested stem scars enable rapid infiltration by any water that contacts the scar surface. With water congested stem scars, dump tank or flume water can readily enter the fruit during the 30 to 60 seconds that it floats in the flumes. Whether fruit harvested during wet conditions have water congested stem scars is unclear.

Holding fruit overnight before packing them should reduce their water uptake tendencies for two reasons. First, the stem scars would start drying and secondly, some of the field heat would dissipate, thereby reducing the direct tendency of the fruit to absorb water and also reducing the amount of heating required to prevent infiltration due to fruit cooling. Holding fruit overnight does increase the decay hazard, because damaged and diseased fruit can produce inoculum that can contaminate sound fruit. Soft rot lesions can develop among warm fruit within 24 h, but they usually are small, particularly if the fruit are cooled to 20°C. The development of large lesions and partially decayed fruit such as found in major outbreaks normally requires a minimum storage period of 48 to 72-h depending on temperature. Thus, the decay hazard associated with holding fruit in field bins or gondolas overnight may be reduced if field crews can be trained to avoid harvesting partially decayed fruit or if such fruit are not found on the plants.

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Table 1. Water uptake for two harvests of Jay Scott's variety test at Bradenton, Florida. Spring, 2004.

Cultivar[a]	First Harvest (g water/fruit)		Second Harvest (g water/fruit)	
Florida-91	1.45	a[b]	1.10	a
Florida-47	1.40	a	1.13	a
Fbl 8092	0.96	a	1.14	a
Fbl 8224	0.92	b	0.84	b
Fbl 8153	0.86	b	0.57	c
Fbl 8093	0.79	bc	0.64	bc
Fbl 8135	0.72	bcd	0.83	b
Solar Fire	0.51	cde	0.29	d
Sebring	0.45	de	0.30	d
Soraya	0.37	e	0.22	d

[a] Within 24 h of harvest, tomatoes were submerged in water and exposed to a simulated immersion depth of 4 feet for 2 min.

[b] Values not followed by the same letter were significantly different at P=0.05 by the Waller/Duncan Multiple Range Test.

Table 2. Cultivar comparison for water uptake, Spring 2004, Bradenton.

Cultivar	Tested 4 h after harvest (g/fruit)		Tested 24 h after harvest (g/fruit)	
Florida 91	0.71	a	0.67	a
Florida 47	0.71	a	0.68	a
Sanibel	0.68	a	0.37	b
Solar Set	0.52	ab	0.41	ab
Solar Fire	0.36	bc	0.22	b
Sebring	0.17	c	0.16	b

[a] Within 4 or 24 h of harvest, tomatoes were submerged in water and exposed to a simulated immersion depth of 4 feet for 2 min.

[b] Values not followed by the same letter were significantly different at P=0.05 by the Waller/Duncan Multiple Range Test.

Table 3. Cultivar comparison for water uptake, Spring 2004, two harvests at Quincy.

Cultivar	First Harvest (g/fruit)[a]		Second Harvest (g/fruit)[b]	
Florida MH-1	0.81	a[c]	1.49	a
Florida 91	0.67	ab	1.02	b
Florida 47	0.41	bcd	0.97	b
Solar Set	0.48	abc	0.86	b
Sanibel	0.37	bcd	0.40	c
Solar Fire	0.17	cd	0.38	c
Sebring	0.16	cd	0.22	c
Peto 882	0.02	d	0.11	c

[a] Within 24 h of harvest, tomatoes were submerged in water and exposed to a simulated immersion depth of 4 feet for 2 min.

[b] At 5 and 22 after harvest, tomatoes were submerged in water and exposed to a simulated immersion depth of 4 feet for 2 min.

[b] Values not followed by the same letter were significantly different at P=0.05 by the Waller/Duncan Multiple Range Test.

Table 4. Cultivar comparison for water uptake, Spring 2004, second harvest, Quincy

Cultivar	5 hour (g/fruit)[a]		22 hours (g/fruit)[a]	
Florida MH-1	1.60	a[b]	1.32	a
Florida 91	1.22	b	0.82	ab
Florida 47	1.10	b	0.83	ab
Solar Set	1.08	b	0.63	ab
Sanibel	0.57	c	0.23	b
Solar Fire	0.44	cd	0.31	b
Sebring	0.23	cd	0.20	b
Peto 882	0.13	d	0.08	b

[a] At 5 or 22 h of harvest, tomatoes were submerged in water and exposed to a simulated immersion depth of 4 feet for 2 min.

[b] Values not followed by the same letter were significantly different at P=0.05 by the Waller/Duncan Multiple Range Test.

Table 5. Variety trial, Quincy, Spring 2005.

Cultivar	Uptake (g/fruit)[a]	Mean separation[b]
Solar Fire	0.43	a
Fbl 8314	0.24	b
Florida 91	0.19	bc
Florida 47	0.17	bc
Fbl 8153	0.15	bc
Sebring	0.12	bc
Fbl 7964	0.12	bc
Amelia	0.07	c

[a] Within 24 h of harvest, tomatoes were submerged in water and exposed to a simulated immersion depth of 4 feet for 2 min.

[b] Values not followed by the same letter were significantly different at P=0.05 by the Waller/Duncan Multiple Range Test.

An Outbreak of Bacterial Speck on Tomato in the Spring 2005

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Bacterial leaf spots associated with tomato have primarily been bacterial spot incited by *Xanthomonas campestris* pv. *vesicatoria* and bacterial speck incited by *Pseudomonas syringae* pv. *tomato*. In Florida, bacterial spot is the most destructive bacterial disease when high temperatures and excessive moisture occur during fall crops (Pohronezny and Volin, 1983). Bacterial spot is considered a warm weather pathogen and thus in the spring it would not be as aggressive as in the fall. Generally bacterial leaf spot in Florida is not a significant concern to spring crops of tomato because of the typically dry weather.

Bacterial speck is favored by relatively cool weather conditions such as occurred this past spring season. Therefore, it is the more likely candidate to be associated with a spring epidemic. Bacterial speck has been a problem in Florida tomato production during periods of significant rainfall during spring production. Jones and Jones (1983) identified several tomato fields in Manatee County where bacterial speck was a major problem in a spring tomato crop. That particular year was cool and extremely wet. In the past bacterial speck has been a chronic problem in the Homestead area during winter tomato production to a large extent because of the use of overhead irrigation.

The spring of 2005 was unusually wet and was conducive for bacterial diseases. A number of fields were affected by what was thought to be bacterial leaf spot. The fruit was also affected although there it was unusual in appearance. The lesions were large, sunken and distinctly black. They resembled bacterial speck more than bacterial spot, although the lesions were atypical in their rather large size (Figure 1a) unlike the "speck" size lesions normally observed on the fruit. Large fruit lesions caused by the bacterial speck pathogen, although rare, have been observed previously in Florida by Dr. K. L. Pernezny (personal communication). Although bacterial speck does occur frequently on fruit, only very young developing fruit are susceptible. Furthermore, it requires optimal conditions and inoculum for infection as was demonstrated by Getz et al. (1983) for bacterial speck and by Scott et al. (1989) for bacterial spot. In both studies it was demonstrated that fruit infection only occurs during a short time-frame following anthesis.

In order to conclusively show that this was bacterial speck, isolations were made from lesions representing samples from three fields. In all the lesion samples a bacterium was present which was characteristic of the bacterial speck pathogen (*Pseudomonas syringae* pv. *tomato*) and in a number of isolations we recovered two types of organisms, the bacterial speck pathogen and another one that was characteristic of the bacterial spot pathogen (*Xanthomonas campestris* pv. *vesicatoria*). The strains that were suspected of being the bacterial speck pathogen were typical *P. syringae* pv. *tomato* strains based on several bacteriological tests including fatty acid analysis. A representative strain was used to inoculate young tomato plants. Typical bacterial speck symptoms developed and confirmed that this was the bacterial speck pathogen and not one of the weaker pathogenic fluorescent pseudomonads that is often associated with tomato. We determined the race for seven of the strains and all were race 0 based on their ability to induce a hypersensitive reaction following infiltration in Rio Grande-*PtoR* supplied by. G. Martin (Boyce Thompson Institute, Ithaca, NY). Therefore tomato genotypes carrying the *Pto* gene in all likelihood would have been resistant to these strains.

We inoculated some very young fruit in the greenhouse to determine if large fruit lesions could be reproduced. Young fruit were inoculated by gently rubbing the bacterial suspension of one of the *P. syringae* pv. *tomato* strains, one of the *X. campestris* pv. *vesicatoria* strains and a mixture of both strains. The lesions on fruit inoculated with the *P. syringae* pv. *tomato* strain only or the mixture were large, sunken black lesions (Fig. 1B) very similar to the field lesions, whereas lesions on the fruit inoculated with the xanthomonad were small necrotic lesions, atypical of bacterial spot lesions. Therefore, we conclusively demonstrated that *P. syringae* pv. *tomato* can cause large speck lesions.

Control of bacterial spot and bacterial speck requires an intensive program. Transplants must be free of bacterial diseases going into the field. The fields also need to be isolated from production fields from the previous season given that bacterial cells can be transported long distances to infect healthy crops. It is important to eliminate sources of inoculum such as volunteers or adjacent fields as sources of inoculum. Bactericides are also an important component of an integrated approach for controlling bacterial diseases of tomato. Copper has been used for many years and has been shown many times to be significantly more effective if applied in a tank mix with an EBDC compound. A second group of compounds that have proven effective are plant activators. Actigard has been shown in many studies to reduce bacterial spot and bacterial speck disease severity (Louws et al., 2001). A very promising approach for controlling bacterial spot has been to use bacteriophages (Flaherty et. al., 1999; Balogh et al., 2001; Obradovic et al., 2004). We have demonstrated in the field that bacteriophage applications result in significantly higher fruit yields compared to the control or other standard treatments. A similar strategy should be effective for controlling bacterial speck.

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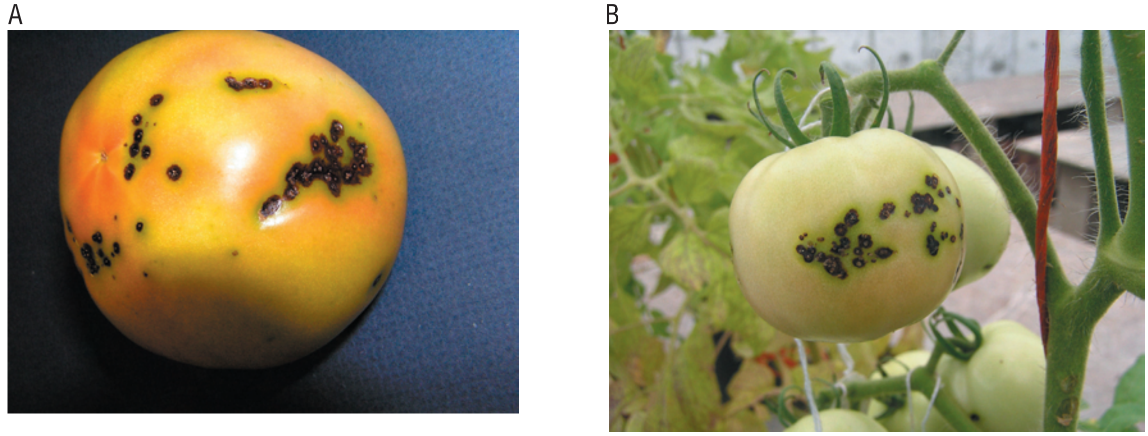

Figure 1. A) Bacterial speck lesions associated with tomato fruit in Florida in spring of 2005. Note the typical small (speck-like) lesions and the larger atypical lesions. **B)** Artificial inoculation with the bacterial speck pathogen.

Use of VIF and Metalized Mulches with Reduced Methyl Bromide Rates in Tomato

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Methyl bromide (MBr) alone, or in combination with chloropicrin (Pic), has been the soil fumigant of choice since the early 1970s (Overman and Martin, 1978), because of its ease of use and high efficacy under a wide range of conditions. It is typically shank-injected at 350 lb/acre to a soil depth of 10 inches into raised beds that are simultaneously covered with LDPE mulch. Standard LDPE is inexpensive and easy to use, but it is highly permeable to MBr (Gamliel et al., 1998a, 1998b; Papiernik and Yates, 2001; Williams et al., 1999; Yates et al., 1996a, 1996b). MBr has been classified as a substance that contributes to depletion of stratospheric ozone. Consequently, a complete phase-out of the use and production of MBr in developed countries throughout the world was scheduled to occur by 2005, with critical use exemptions permitted under the Montreal Protocol (U.S. Environmental Protection Agency, 1999). Critical use exemptions (CUE) are important for minor crops because growers feel that an economically and technically viable MBr alternative is not yet commercially available. However, even with permitted exemptions, reduced rates of MBr may be needed to offset the rising cost of the fumigant and to reduce atmospheric emissions. Reduced emissions probably will be a requirement for future CUEs.

To obtain a high degree of pest control with a fumigant, it is necessary to maintain a sufficient quantity of fumigant gas in the soil long enough to reduce the population of pests (Gamliel et al., 1998b; Minuto et al., 1999). This might be accomplished by using low rates of MBr under highly retentive or reduced permeability film. Virtually impermeable film (VIF) is so named due to the much higher fumigant retention capacity of this film compared to ldpe and hdpe which have been the historical mainstays of plasticulture. VIF has become commercially available in recent years and is much more retentive of fumigant gases than standard ldpe mulch (Papiernik and Yates, 2001). This type of film increases fumigant toxicity by increasing the duration of retention, which is caused by a barrier polymer, such as ethylene vinyl alcohol or nylon, placed between two layers of polyethylene (Papiernik and Yates, 2001). Wang et al. (1997) determined that atmospheric emission of Mbr, when covered with polyethylene for 5 days, declined from 64% of applied MBr with conventional LDPE mulch to about 38% with VIF. With the soil covered by VIF for more than 10 days, only 1% to 3% of the MBr was lost.

In the past 6 years, considerable field research and grower trials have been conducted with these VIF mulches in Florida. Small plot studies demonstrated that nutsedge and stunt nematodes could be controlled and crop yields maintained with rates of methyl bromide / chloropicrin (67/33 formulation) as low as one-fourth (88 lb./treated acre) of the standard use rate of 350 lb./treated acre when combined with some VIF mulch films, while grower trials successfully established the commercial potential of one-half normal rates (Gilreath et al, 2005a; Santos et al, 2005). Additional research indicated that this improvement in fumigant retention and control of soilborne pests with VIF was not restricted to just methyl bromide, but also included 1,3-D-based fumigants like Telone C-35 and Inline (Gilreath et al, 2004; Hochmuth et al, 2003). Preliminary data indicate similar results with other fumigants such as Midas.

Unfortunately, there are 2 drawbacks to most VIF products: cost and handling characteristics. Today, all VIF is made in Europe and must be imported, thus resulting in much higher cost than standard film. Also, most of the VIF products are more difficult to lay than standard films in that they are prone to linear sheer if subjected to too much tension during laying. There is considerable difference in handling characteristics among VIF materials, but they are all based on polyamides, such as nylon, for their barrier properties and these polyamides do not stretch well. Also, none are embossed at the present time. High barrier films continue to be evaluated as they become available, but to date Bromostop ® VIF has been the most consistent performer and appears to handle the best under our conditions.

Recognizing the problems associated with some of the existing VIF, we continue to search for other mulch films with enhanced barrier properties. Over the past 2 years, we have examined the barrier properties of metalized films under field conditions, first with 1,3-D (Inline) and more recently with methyl bromide. In each case, application of Inline or methyl bromide in conjunction with metalized film greatly increased the retention of the fumigant (Gilreath et al, 2005b). In the case of methyl bromide, we were able to obtain nutsedge control with 175 lb./acre of 67/33 under Canslit ® metalized film that was equal or superior to that obtained with the full 350 lb./acre rate under standard ldpe or hdpe film in each of four experiments. Bromostop ® VIF was included in each of these experiments and the field performance for gas retention under the mulch film, as well as nutsedge control and fruit production, was similar between Canslit ® metalized film and VIF. Grower trials with Canslit ® metalized film confirmed these results. Additionally, we determined that the retention of methyl bromide and resultant nutsedge control with Canslit ® metalized film was similar to what we obtained with VIF at every rate of methyl bromide, ranging from 88 to 350 lb./acre of 67/33.

While it is possible to use Bromostop ® VIF or Canslit ® metalized film to reduce methyl bromide usage rates by one-half, successful use involves more than just reducing gas flow and laying mulch film. Methyl bromide has a high vapor pressure, which means that at typical application temperatures it rapidly becomes a gas and can do so even within the tubing and gas knives of the application rig. This is an advantage for reduced rate application, but it does not solve one inherent problem - uniformity of application. Typical gas rigs employ 3 knives per bed. A good fumigation job requires that all 3 knives deliver the same amount of product per minute so that the application rate is uniform in the area being fumigated. When the rate is reduced, there is less fumigant in the system and more opportunity for the formation of bubbles as the methyl bromide "boils". This "boiling" easily can be visualized by inserting small sight glasses in the application equipment at the flow divider just ahead of the tubes which carry the fumigant to the knives. Under normal conditions, a certain amount of back pressure exists in the application system and can be measured at the flow divider by installing a pressure gauge. Application of a full 350 lb./acre rate will generate in excess of 30 psi of back pressure at this point. Reducing the methyl bromide flow rate in order to deliver lower rates per acre will reduce the back pressure measured at the flow divider. Our experience indicates that back pressure below 15 psi results in nonuniform distribution to the three knives which means inequalities in rate across the bed. Usually the edges suffer the most and this effect can be observed later in the season as poor control of nutsedge on bed shoulders.

In order to increase back pressure when using low rates of methyl bromide or any other fumigant, you must decrease the flow capacity of the delivery system between the flow divider and the gas knives. This can be accomplished in two ways. First, you can use a smaller diameter tubing to deliver fumigant to the gas knives. Standard gas rigs use tubing which is one-quarter inch inside diameter. While this is fine for a gas with high vapor pressure like methyl bromide or for high flow rates of other fumigants, it may not be suitable in other situations. We have found that the use of poly tubing ranging from one-sixteenth to one-eighth inch inside diameter is necessary in order to achieve balanced or uniform delivery of greatly reduced rates of methyl bromide. Tubing of this size is not readily available, but it can be obtained and is an important modification if a grower is going to use reduced rates of methyl bromide with a highly retentive film like Canslit ® metalized or Bromostop ® VIF. Fine tuning of flow capacity or rate of any tube can be accomplished by increasing or decreasing the length of the tube connecting the flow divider to the gas knife. There is a certain amount of friction loss of flow within any size tube and the effect of friction increases with increased length and decreased tubing inside diameter. Typical length for one-sixteenth and one-eighth inch tubing is 5 ft; although longer tubing has been used when trying to achieve really low rates. Color coded tubing is available which can be a big help when adjusting flow rates. Yellow tubing has the thickest walls and smallest inside diameter of one-sixteenth inch. Black tubing is available in one-eighth inch inside diameter. These tubes all fit the same size connector, making it easy to switch from one flow capacity to another. Select the tube needed for the desired flow capacity, then once installed, adjust the flow regulator valve for the required flow rate on the flow meter, just like normal.

A second way to decrease flow and increase back pressure is to use orifice plates (Teejet ® flow regulators) in the tubing at the top of the gas knife fitting. In order to use these plates, you have to know what flow rate you need in each tube. Since the flow rates of orifice plates are based on water, you have to do some mathematical conversions to methyl bromide or choose one on the high side and try it. In any event, you do not want a plate which gives you the exact same flow rate as what you need; you want one with a slightly higher flow rate so that clogging potential is lowered. If you are going to use orifice plates, you should keep a supply of various sizes on hand. The plates have numbers stamped on them which tell you the size of the hole in the plate. Be sure to keep your glasses handy because these can be hard to read. Orifice plates work over a more narrow range of rates than tubing because the restriction in flow occurs at one point rather than over a length of tubing.

The system we use is commercially available (manufactured by Mirruso Enterprises, Inc., available through Chemical Containers, Inc.) and constitutes an easily installed, simple modification. It consists of a flow divider with a small sight glass for each knife, a 0 to 30 psi pressure gauge and small diameter poly tubing. The sight glasses are equipped with standard quick connect (insert friction connectors) couplings on top so the poly tube easily can be connected and disconnected. Similar couplings are located on the top of the gas knives. Sight glasses are useful because they allow you to monitor flow and detect plugging of chisels or lines. Plugging can be a significant issue with low rates of fumigant. As a result, fumigant filtration is even more important and filters need to be checked periodically and maintained clean and free of trash to assure consistent flow through the fumigant distribution system.

One thing to remember when using reduced rates of fumigant: the flow rate has been greatly diminished so accuracy and uniformity of delivery are critical. A common observation on commercial farms is tractor movement as soon as the fumigant flow valve is opened. There is a much longer delay in supplying all the knives uniformly when the rate is reduced, so tractor movement should not begin until all lines are fully charged. This condition easily can be monitored by observing the sight gauges and back pressure gauge. Once the back pressure stabilizes, fumigation can begin. Addition of an inline check valve at the top of each gas knife can be beneficial because it diminishes loss of fumigant out of the line to the knife. By keeping the line full all the way to the gas knife, there are fewer delays in fumigant delivery and less time wasted purging air from lines. This would be especially important for those growers who use radar controlled fumigant delivery systems.

Rate reduction with methyl bromide works when combined with a highly retentive mulch film like VIF or metalized film. In addtion to the use of the right film, success requires close monitoring of fumigant delivery, assuring not only that the rate is correct, but also that it is applied uniformly to all three knives in the bed. Nonuniformity guarantees poor fumigant performance at any rate, but with reduced rates of methyl bromide, the results can be even more dramatic. The simple modifications described above can greatly improve uniformity of delivery and performance. These modifications are relatively inexpensive and are readily available as a package. Before trying rate reductions growers should modify their fumigation equipment to allow better control over uniformity of flow. This can mean the difference between success and failure. Under no conditions should a grower attempt to reduce his methyl bromide rate by more than 50% of the standard use rate the first time around. Rates lower than 50% are possible, but it is difficult to achieve the required level of application uniformity and accuracy without considerable experience and attention to detail. Growers should gain experience with rate reduction and use of barrier films because this will be the future and the future is now.

IMPORTANT FACTS TO CONSIDER

✓ Not all VIF or metalized films are the same.

✓ Gas retention with VIF mulch is fairly consistent among manufacturers, but handling properties may differ greatly.

✓ Gas retention among metalized films may vary by manufacturer. Not all have been tested at this time.

✓ One manifestation of non-uniformity of delivery of fumigant may be nutsedge on the bed shoulders but not in the middle of the bed.

✓ Rate reduction requires close attention to uniformity of application.

✓ Uniformity requires balanced flow between all chisels or knives.

✓ Balanced flow requires sufficient back pressure on gas lines (at least 15 psi at the flow divider).

✓ Back pressure can be achieved by impeding flow at the chisels.

✓ Reduced flow rate at the chisel can be obtained by reduction of line size (1/8th to 1/16th inch inside diameter) from the flow divider to the chisel or by using Teejet ®) flow regulators (orifice plates).

✓ Back pressure can be adjusted by selecting the length and inside diameter of small diameter tubing from the flow divider to the chisel or by selection of the proper size orifice plate based on mathematical calculations.

✓ Methyl bromide rates of ½ the normal 350 lb. / treated acre rate generally require at least 5 ft of 1/8th inch inside diameter tubing from the flow divider to each chisel.

✓ Methyl bromide rates below 175 lb./treated acre may require 5 or more feet of 1/16 inch inside diameter tubing.

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"Q" Biotype Whitefly: How Big a Threat?

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A new strain of *Bemisia tabaci*, "Q" biotype, was first detected in the US on poinsettias purchased at a retail outlet during December 2004 in Tucson by a team from the University of Arizona. The plants were said to have been purchased from a wholesale dealer in California. Although indistinguishable in appearance from silverleaf whitefly, these insects proved markedly less susceptible to pyriproxyfen, buprofezin, imidacloprid, acetamiprid, and thiamethoxam. Electrophoresis, polymerase chain reaction (PCR) and sequencing of the mitochondrial cytochrome oxidase 1 gene revealed their unique genetic identity. The debut of a new whitefly on poinsettia is reminiscent of a scenario 19 years ago that culminated in unprecedented losses for Florida tomato growers and a new pest pandemic. Are we in for an equally devastating invasion?

History of Whitefly Biotypes

Prior to 1986, *B. tabaci*, known as the sweetpotato whitefly, was thought to be pretty much the same everywhere it occurred throughout the tropics, subtropics and mild temperate regions of the world. Then massive numbers suddenly turned up in greenhouse poinsettias in Florida, spreading quickly to field grown vegetables and other crops (Price 1987). Clouds of whiteflies in tomato fields produced quantities of sooty mold and a nuisance for pickers, followed by a new plant disorder, tomato irregular ripening (Schuster et. al. 1990) and a new geminivirus, Tomato Mottle (Polston and Anderson 1997). First dubbed the "poinsettia" whitefly or even the "Florida" whitefly, it came to be known as *B. tabaci* biotype "B" to distinguish it from the former biotype "A". Biotype "A" had been relatively benign in Florida but caused serious losses in California and Arizona as a cotton pest and a vector of the "crinivirus" lettuce infectious yellows in lettuce and melons (Duffus 1995).

The term "biotype" is synonymous with "strain" or even "subspecies" and biotypes of the same species should be able to produce fertile offspring when crossed. Although biotypes of *B. tabaci* cannot be separated visually, biotype "B" was described in 1994, though not universally accepted, as a new species, *Bemisia argentifolii* or "silverleaf" whitefly (Bellows et. al. 1994). Species status was conferred on the basis of biological differences such as the ability to cause physiological disorders such as squash silverleaf or tomato irregular ripening, as well as failure to produce hybrids with biotype "A" whiteflies in the laboratory (Perring et. al 1993).

Since the discovery of the silverleaf whitefly, numerous other biotypes of *B. tabaci* have been described on the bases of genetic differences at the molecular level and some biological distinctions (Costa et al. 1991; Frohlich et al. 1999). These biotypes form two main groups, New World types and Old World types. The Old World types are more diverse, and often exhibit broader host ranges that facilitate maintenance of high populations within different agroecosystems, and movement of viruses among crops. Old world types include the "B" biotype probably originating in southwestern Asia, and the "Q" biotype that dominates in much of the Mediterranean region (De Barro et al. 2005).

"B" VS "Q"

The "B" and "Q" biotypes are similar genetically and in many of their biological characteristics. Both are major pests of a wide range of crops including most vegetables. Both transmit TYLCV, although "Q" is reported as a more efficient vector than "B" (Sánchez-Campos et al. 1999). Both may also move many other geminiviruses as well as a number of criniviruses including tomato chlorosis and tomato infectious chlorosis ("TIC" and "TOC") (Jones 2003). However, there are also some notable differences. "Q" only causes squash silverleaf and tomato irregular ripening at very high infestation levels in contrast to "B". On the other hand, Q appears to quickly evolve resistance to the most commonly used insecticides for whitefly control (Cahill et al. 1996a, 1996b). That means "Q" will probably out-compete "B" under selective pressure from insecticides. Furthermore, the resistance appears to be stable, meaning that it does not diminish over time. However, resistance has its cost, and in the absence of

Table 1. Comparison of biological characteristics of "B" vs "Q" biotypes.

Characteristic	Biotype "B"	Biotype "Q"
Biotic potential	xxxx	xxx
Host plant range	xxxx	xxxx
TYLCV vector	xxx	xxxx
Plant disorders	xxxx	x
Insecticide resistance	xx	xxxx
Biological control candidate	xxx	xxxx

x = weak, xx = moderate, xxx = strong, xxxx = very strong.

insecticides “B”, with its presumably greater biotic potential, will likely out-compete “Q” on most crops (Beitia et al. 1997). It may also be true that “Q” is more readily attacked than “B” by certain parasitic wasps, notably *Eretmocerus mundus* which was released in the US from Spain (Stansly et al 2004, 2005). A similar species, *E. near emiratus* has come be the dominant parasitoid attacking *B. tabaci* in parts of Florida and California and would certainly be a positive element in managing “Q”. However, many of these presumed differences, summarized in the table below, require experimental confirmation.

LIKELY IMPACT OF BIOTYPE “Q” IN FLORIDA

The new biotype will certainly not reek anything like the havoc that followed the last whitefly invasion. Biotype “B” rapidly overwhelmed the old “A” biotype whitefly in Florida and elsewhere with its ability to build up high populations on numerous different crops. In contrast, “Q” would find itself faced with well established populations of “B” on virtually any potential host plant and may not compete effectively unless assisted by insecticidal selection. Thus, Q might not achieve a foothold in dooryard ornamentals but could in production greenhouses where a captive whitefly population might be continually exposed to a limited toolbox of products. Thus, the first control problems are most likely to appear in the greenhouse/screenhouse ornamental industry, as presaged by the find in Arizona.

WHITEFLY SURVEYS: PAST AND PRESENT

An extensive survey of *B. tabaci* populations in 15 economically important crops (including tomato) and 8 weed species in Florida was conducted from March 2000 to May 2001 (McKenzie et al. 2004). Biotype analysis by RAPD/PCR indicated the presence of only the B biotype of *B. tabaci* in all collections. These data suggested that in Florida, the B biotype of *B. tabaci* had excluded the native non-B biotypes (A biotype) in agricultural ecosystems. Whitefly surveys were resumed in 2005 after the discovery of the “Q” biotype in California and Arizona and figure 1 indicates the locations of sample sites by county, past and present. Since the “Q” biotype was found in the U.S., samples have been collected and analyzed in Florida from Naples (Collier), Palm Bay (Brevard), Homestead (Dade), Parrish (Manatee), New Port Richey (Pasco), Vero Beach (Indian River), Tallahassee (Leon), and Altamonte Springs (Seminole). Currently, only the B biotype has been detected in Florida. In cooperation with APHIS, DPI, USDA-ARS and University researchers and concerned growers across the state, extensive surveying of Florida will continue to determine if the “Q” biotype has invaded Florida. The goal of the survey is to first identify and then monitor apparent movement of the “Q” biotype and predict downstream impacts on crops and areas. The highest priority should be on sampling greenhouses, and whitefly host crops in proximity to greenhouses as well as retail outlets such as Home Depot. Knowing who and where the enemy is has always been the foundation of a good IPM program and should aide growers in making sound management decisions.

ACTION PLAN

Soon after discovery in Arizona, an ad hoc Q-Biotype Whitefly Taskforce was formed of interested scientists and administrators from the regulatory and research communities. Officials from USDA-APHIS Plant Protection and Quarantine (PPQ) stated that their agency would apply the current policy for the B-Biotype of the whitefly, *Bemisia tabaci* (“non-reportable/non-actionable”), to the recently detected Q-Biotype. Thus, there will be no specific federal barriers to movement of this pest. As yet there has been no policy statement from Florida DACS-DPI, but it seems unlikely that movement of whitefly-infested plant material will be regulated in Florida either. However, both agencies are cooperating in a national monitoring effort to track movement of “Q” biotype, and so far (June 2005), there have been no new reports of “Q” biotype in the US. Additionally, entomologists at the Universities of Arizona and California have embarked on a program to evaluate insecticide susceptibility of the “Q” biotype populations in their respective states.

As movement of the new pest and associated control problems become more apparent, additional research will be directed at ways to mitigate the impact. Meanwhile growers and consultants are advised to keep a sharp lookout for unusual whitefly activity, and to apply even more rigorously the principals of IPM and resistance management that have served us well in the past. Mitigating the threat of biotype “Q” is just one more reason to practice good IPM and resistance management practices: (1) use insecticides only as needed based on scouting, (2) employ alternate management strategies such as host free periods, clean transplants, rouging of symptomatic plants, (3) limit exposure of whiteflies to neonicotinoids by using only once in tomato and abstaining if possible in other crops, (4) rotate classes of insecticide. Sound insecticide management is our best insurance against biotype “Q” and the increased threat of insecticide resistance that it represents.

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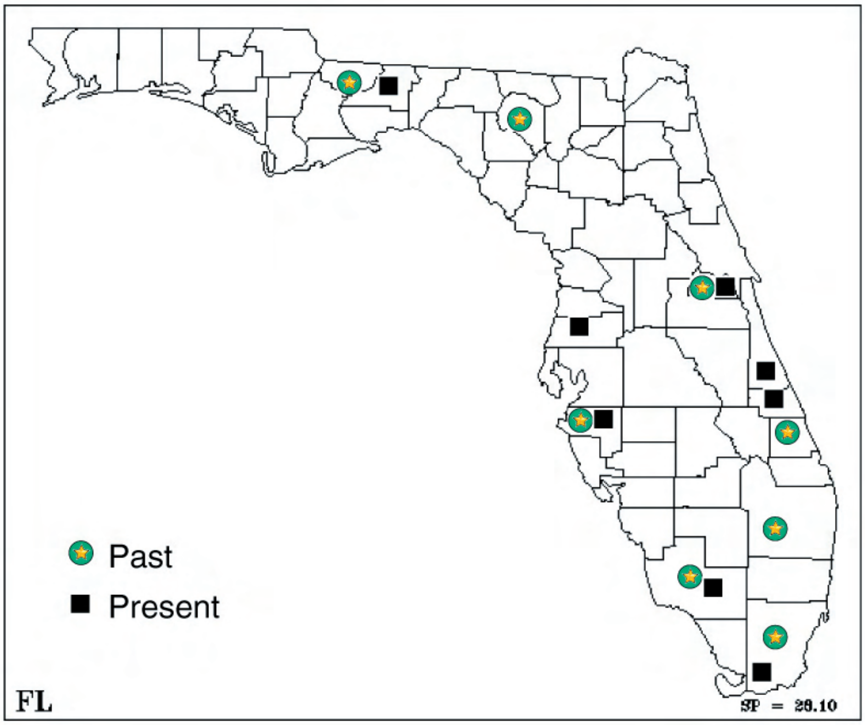

Figure 1. Whitefly surveys conducted in Florida by county, past (2000-2001) and present (2005).

Tomato Varieties for Florida

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Variety selections, often made several months before planting, are one of the most important management decisions made by the grower. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability.

The following characteristics should be considered in selection of tomato varieties for use in Florida.

- **Yield** - The variety selected should have the potential to produce crops at least equivalent to varieties already grown. The average yield in Florida is currently about 1400 25-pound cartons per acre. The potential yield of varieties in use should be much higher than average.

- **Disease Resistance** - Varieties selected for use in Florida must have resistance to Fusarium wilt, race 1, race 2 and in some areas race 3; Verticillium wilt (race 1); gray leaf spot; and some tolerance to bacterial soft rot. Available resistance to other diseases may be important in certain situations, such as Tomato Spotted Wilt and Bacterial Wilt resistance in northwest Florida.

- **Horticultural Quality** - Plant habit, stem type and fruit size, shape, color, smoothness and resistance to defects should all be considered in variety selection.

- **Adaptability** - Successful tomato varieties must perform well under the range of environmental conditions usually encountered in the district or on the individual farm.

- **Market Acceptability** - The tomato produced must have characteristics acceptable to the packer, shipper, wholesaler, retailer and consumer. Included among these qualities are pack out, fruit shape, ripening ability, firmness, and flavor.

CURRENT VARIETY SITUATION

Many tomato varieties are grown commercially in Florida, but only a few represent most of the acreage. In years past we have been able to give a breakdown of which varieties are used and predominantly where they were being used but this information is no longer available through the USDA Crop Reporting Service.

TOMATO VARIETY TRIAL RESULTS

Summary results listing the five highest yielding and the five largest fruited varieties from trials conducted at the University of Florida's Gulf Coast Research and Education Center, Bradenton; Indian River Research and Education Center, Ft. Pierce and North Florida Research and Education Center, Quincy for the Spring 2004 season are shown in Table 1. High total yields and large fruit size were produced by Fla. 8092, FL 47 and FL 91 at Ft. Pierce and BHN 444 at Quincy. There was very little overlap between locations. The same entries were not included at all locations.

TOMATO VARIETIES FOR COMMERCIAL PRODUCTION

The varieties listed have performed well in University of Florida trials conducted in various locations in recent years.

LARGE FRUITED VARIETIES

Amelia. Vigorous determinate, main season, jointed hybrid. Fruit are firm and aromatic suitable for green or vine ripe. Good crack resistance. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1, 2 and 3), root-knot nematode, gray leaf spot and Tomato Spotted Wilt. **For Trial.** (Harris Moran).

BHN 640. Early-midseason maturity. Fruit are globe shape but tend to slightly elongate, and green shouldered. Not for fall planting. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1, 2 and 3), gray leaf spot, and Tomato Spotted Wilt. **For Trial.** (BHN).

HA 3073. A midseason, determinate, jointed hybrid. Fruit are large, firm, slightly oblate and are uniformly green. Resistant: Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot, Tomato Yellow Leaf Curl Virus and Tomato Mosaic Virus. **For Trial.** (Hazera)

Florida 47. A late midseason, determinate, jointed hybrid. Uniform green, globe-shaped fruit. Resistant: Fusarium wilt (race 1 and 2), Verticillium wilt (race 1), Alternaria stem canker, and gray leaf spot. (Seminis).

Florida 91. Uniform green fruit borne on jointed pedicels. Determinate plant. Good fruit setting ability under high temperatures. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, and gray leaf spot. (Seminis).

Sebring. A late midseason determinate, jointed hybrid with a smooth, deep oblate, firm, thick walled fruit. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1, 2 and 3), Fusarium crown rot and gray leaf spot. (Syngenta)

Solar Fire. An early, determinate, jointed hybrid. Has good fruit setting ability under high temperatures. Fruit are large, flat-round, smooth, firm, light green shoulder and blossom scars are smooth. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1, 2 and 3) and gray leaf spot. **For Trial.** (University of Florida)

Solar Set. An early, green-shouldered, jointed hybrid. Determinate. Fruit set under high temperatures (92°F day/72° night) is superior to most other commercial varieties. Resistant: Fusarium wilt (race 1 and 2), Verticillium wilt (race 1), Alternaria stem canker, and gray leaf spot. (Seminis).

Solimar. A midseason hybrid producing globe-shaped, green shouldered fruit. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot. (Seminis).

Tygress. A midseason, jointed hybrid producing large, smooth firm fruit with good packouts. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot, Tomato Mosaic Virus and Tomato Yellow Leaf Curl Virus. **For Trial.** (Seminis).

PLUM TYPE VARIETIES

Marina. Medium to large vine determinate hybrid. Rectangular, blocky, fruit may be harvested mature green or red. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, root-knot nematodes, gray leaf spot, and bacterial speck. (Sakata).

Plum Dandy. Medium to large determinate plants. Rectangular, blocky, defect-free fruit for fresh-market production. When grown in hot, wet conditions, it does not set fruit well and is susceptible to bacterial spot. For winter and spring production in Florida. Resistant: Verticillium wilt, Fusarium wilt (race 1), early blight, and rain checking. (Harris Moran).

Spectrum 882. Blocky, uniform-green shoulder fruit are produced on medium-large determinate plants. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), root-knot nematode, bacterial speck (race 0), Alternaria stem canker, and gray leaf spot. (Seminis).

Supra. Determinate hybrid rectangular, blocky, shaped fruit with uniform green shoulder. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), root-knot nematodes, and bacterial speck. (Syngenta).

Veronica. Tall determinate hybrid. Smooth plum type fruit are uniform ripening. Good performance in all production seasons. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, nematodes, gray leaf spot and bacterial speck. (Sakata).

CHERRY TYPE VARIETIES

Mountain Belle. Vigorous, determinate type plants. Fruit are round to slightly ovate with uniform green shoulders borne on jointless pedicels. Resistant: Fusarium wilt (race 2), Verticillium wilt (race 1). For trial. (Syngenta).

Cherry Grande. Large, globe-shaped, cherry-type fruit are produced on medium-size determinate plants. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1), Alternaria stem blight, and gray leaf spot. (Seminis).

GRAPE TOMATOES

Grape tomatoes are elongated cherry type tomatoes with very sweet fruit and fruit length about twice that of the diameter. The fruit usually weigh about 1/3 to ½ oz. The plant habit and fruit flavor are very similar to Sweet 100 and Sweet Million, two old indeterminate cherry varieties. These varieties had limited commercial use due to plant growth habit and severe fruit cracking. The original 'grape' tomato variety was Santa, a high quality indeterminate variety. Santa is a proprietary variety and has limited availability. St. Nick is another indeterminate variety that is available. There are also available several new indeterminate varieties available but information is limited. Also on the market are several determinate varieties such as Sweet Olive and Jolly Elf, but flavor is not as good as the older indeterminates. There are also new yellow and pink varieties available. Most of the grape varieties are fairly resistant to fruit cracking.

REFERENCE

This information was gathered from results of tomato variety trials conducted during 2004 at locations specified in each table.

Tomato variety evaluations were conducted in 2004 by the following University of Florida faculty:

J.W. Scott, Gulf Coast Research & Education Center - Balm

S. M. Olson, North Florida Research & Education Center - Quincy

P. J. Stoffella, Indian River Research & Education Center - Fort Pierce

Table 1. Summary of University of Florida tomato variety trial results. Spring 2004.

Location	Variety	Total yield (ctn/acre)	Variety	Average fruit wt. (oz)
Bradenton	Fla. 8092	2555	Soraya	7.3
	ACR-242-XLT	2393	Biltmore	7.1
	Fla. 8135	2341	Sebring	7.1
	Fla. 8093	2268	Tygress	7.0
	Fla. 8224	2245[1]	FL 91	6.9[2]
Fort Pierce	FL 91	3148	FL 91	8.2
	Fla. 8092	3048	FL 47	8.0
	FL 47	2967	Fla. 8092	7.4
	Solar Fire	2849	Fla. 8135	7.2
	Fla. 8135	2682[3]	Fla. 8224	6.9[4]
Quincy	BHN 444	2259	BHN 444	9.3
	Crista	2018	SVR 01409432	8.6
	BHN 640	1958	Tygress	8.6
	Quincy	1867	Biltmore	8.6
	Amelia	1841[5]	NC 0227	8.2[6]

[1] 14 other entries had yields similar to Fla. 8224.

[2] 9 other entries had fruit weight similar to FL 91.

[3] 3 other entries had yields similar to Fla. 8135.

[4] 3 other entries had fruit weight similar to Fla. 8224.

[5] 23 other entries had yields similar to Amelia.

[6] 19 other entries had fruit weight similar to NC 0227.

Seed Sources:

Abbott & Cobb: ACR-242-XLT.

BHN Seed: BHN 444, BHN 640.

Harris Moran: Amelia, Crista, Solar Fire.

North Carolina State: NC 0227.

Seminis: Biltmore, FL 47, FL 91, Quincy, Tygress, SVR 01409432.

Syngenta: Sebring, Soraya.

Water Management For Tomato

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Approximately 40,000 acres of tomatoes were harvested in Florida during the 2003-2004 growing season. The value of the fresh-market tomato crop that year was estimated at slightly above $508 million (USDA, National Agricultural Statistics Service, Vegetable Summary; http://jan.mannlib.cornell.edu/reports/nassr/fruit/pvg-bban/vgan0103.txt). The main areas of production are Gadsden county (Quincy), the middle Suwanee Valley, Manatee County (Palmetto-Ruskin), Hendry county (southeast cost), Palm Beach county (southwest coast), and Dade county (Homestead). All tomato production today uses plasticulture (transplants, raised beds, stakes and polyethylene mulch). Tomatoes are irrigated with drip or seepage irrigation.

Water and nutrient management are two important aspects of tomato production in all these production systems. Water is used for wetting the fields before land preparation, transplant establishment, and irrigation. The objective of this article is to provide an overview of recommendations for tomato irrigation in Florida. Recommendations in this article should be considered together with those presented in the "Fertilizer and nutrient management for tomato", also included in this publication.

Irrigation is used to replace the amount of water lost by transpiration and evaporation. This amount is also called crop evapotranspiration (ETc). Irrigation scheduling is used to apply the proper amount of water to a tomato crop at the proper time. The characteristics of the irrigation system, tomato crop needs, soil properties, and atmospheric conditions must all be considered to properly schedule irrigations. Poor timing or insufficient water application can result in crop stress and reduced yields from inappropriate amounts of available water and/or nutrients. Excessive water applications may reduce yield and quality, are a waste of water, and increase the risk of nutrient leaching

A wide range of irrigation scheduling methods is used in Florida, with corresponding levels of water managements (Table 1). The recommended method to schedule irrigation for tomato is to use together an estimate of the tomato crop water requirement that is based on plant growth, a measurement of soil water status and a guideline for splitting irrigation (water management level 5 in Table 1). The estimated water use is a guideline for irrigating tomatoes. The measurement of soil water tension is useful for fine tuning irrigation. Splitting irrigation events is necessary when the amount of water to be applied is larger than the water holding capacity of the root zone

TOMATO WATER REQUIREMENT

Tomato water requirement (ETc) depends on stage of growth, and evaporative demand. ETc can be estimated by adjusting reference evapotranspiration (Eto) with a correction factor called crop factor (Kc; equation [1]). Because different methods exist for estimating ETo, it is very important to use Kc coefficients which were derived using the same ETo estimation method as will be used to determine ETc. Also, Kc values for the appropriate stage of growth and production system (Table 2) must be used.

By definition, ETo represents the water use from a uniform green cover surface, actively growing, and well watered (such as a turf or grass covered area). ETo can be measured on-farm using a small weather station. When daily ETo data are not available, historical daily averages of Penman-method ETo can be used (Table 3). However, these long-term averages are provided as guidelines since actual values may fluctuate by as much as 25%, either above the average on hotter and drier than normal days, or below the average on cooler or more overcast days than normal. As a result, SWT or soil moisture should be monitored in the field.

Eq. [1]
Crop water requirement =
Crop coefficient x Reference evapotranspiration
ETc = Kc x ETo

TOMATO IRRIGATION REQUIREMENT.

Irrigation systems are generally rated with respect to application efficiency (Ea), which is the fraction of the water that has been applied by the irrigation system and that is available to the plant for use. In general, Ea is 20-70% for seepage irrigation and 90-95% for drip irrigation. Applied water that is not available to the plant may have been lost from the crop root zone through evaporation or wind drifts of spray droplets, leaks in the pipe system, surface runoff, subsurface runoff, or deep percolation within the irrigated area. Tomato irrigation requirements are determined by dividing the desired amount of water to provide to the plant (ETc), by Ea as a decimal fraction (Eq. [2]).

Eq. [2]
Irrigation requirement =
Crop water requirement / Application efficiency
IR = ETc/Ea

In areas where real-time weather information is not available, growers use the '1,000 gal/acre/day/string' rule for drip-irrigated, winter production. As the tomato plants grow from 1 to 4 strings, the daily irrigation volumes increase from 1,000 gal/acre/day to 4,000 gal/acre/day. On 6-ft centers, this corresponds to 15 gal/100lbf/ day and 60 gal/100lbf/day for 1 and 4 strings, respectively.

SOIL MOISTURE MEASUREMENT

Soil water tension (SWT) represents the magnitude of the suction (negative pressure) the plant roots have to create to free soil water from the attraction of the soil particles, and move it into root cells. The dryer the soil, the higher the suction needed, hence, the higher SWT. SWT is commonly expressed in centibars (cb) or kiloPascals (kPa; 1cb = 1kPa). For tomatoes grown on the sandy soils of Florida, SWT in the rooting zone should be maintained between 6 (field capacity) and 15 cb.

The two most common tools available to measure SWT in the field are tensiometers and time domain reflectometry (TDR) probes. Tensiometers have been used for several years in tomato production. A porous cup is saturated with water, and placed under vacuum. As the soil water content changes, water comes in or out of the porous cup, and affects the amount of vacuum inside the tensiometer. Tensiometer readings have been successfully used to monitor SWT and schedule irrigation for tomatoes. However, because they are fragile and easily broken by field equipment, many growers do not use them. In addition, readings are not reliable when the tensiometer dries, or when the contact between the cup and the soil is lost. Depending on the length of the access tube, tensiometers cost between $40 and $80 each. Tensiometers can be reused as long as they are maintained properly and remain undamaged.

It is necessary to monitor SWT at two soil depths when tensiometers are used. A shallow 6-in depth is useful at the beginning of the season when tomato roots are near that depth. A deeper 12-in depth is used to monitor SWT during the rest of the season. Comparing SWT at both depth is useful to understand the dynamics of soil moisture. When both SWT are within the 4-8 cb range (close to field capacity), this means that moisture is plentiful in the rooting zone. This may happen after a large rain, or when tomato water use is less than irrigation applied. When the 6-in SWT increases (from 4-8 cb to 10-15cb) while SWT at 12-in remains within 4-8, the upper part of the soil is drying, and it is time to irrigate. If the 6-in SWT continues to raise (above 25cb), a water stress will result; plants will wilt, and yields will be reduced. This should not happen under adequate water management.

A SWT at the 6-in depth remaining within the 4-8 cb range, but the 12-in reading showing a SWT of 20-25 cb suggest that deficit irrigation has been made: irrigation has been applied to re-wet the upper part of the profile only. The amount of water applied was not enough to wet the entire profile. If SWT at the 12-in depth continues to increase, then water stress will become more severe and it will become increasingly difficult to re-wet the soil profile. The sandy soils of Florida have a low water holding capacity. Therefore, SWT should be monitored daily and irrigation applied at least once daily. Scheduling irrigation with SWT only can be difficult at times. Therefore, SWT data should be used together with an estimate of tomato water requirement

Times domain reflectometry (TDR) is not a new method for measuring soil moisture but its use in vegetable production has been limited in the past. The recent availability of inexpensive equipment ($400 to $550/unit) has increased the potential of this method to become practical for tomato growers. A TDR unit is comprised of three parts: a display unit, a sensor, and two rods. Rods may be 4 inches or 8 inches in length based on the depth of the soil. Long rods may be used in all the sandy soils of Florida, while the short rods may be used with the shallow soils of Miami-Dade county.

The advantage of TDR is that probes need not be buried permanently, and readings are available instantaneously. This means that, unlike the tensiometer, TDR can be used as a hand-held, portable tool.

TDR actually determines percent soil moisture (volume of water per volume of soil). In theory, a soil water release curve has to be used to convert soil moisture into SWT. However, because TDR provides an average soil moisture reading over the entire length of the rod (as opposed to the specific depth used for tensiometers), it is not practical to simply convert SWT into soil moisture to compare readings from both methods. Preliminary tests with TDR probes have shown that best soil monitoring may be achieved by placing the probe vertically, approximately 6 inches away from the drip tape on the opposite side of the tomato plants. For fine sandy soils, 9% to 15% appears to be the adequate moisture range. Tomato plants are exposed to water stress when soil moisture is below 8%. Excessive irrigation may result in soil moisture above 16%.

Guidelines for Splitting Irrigation. For sandy soils, a one square foot vertical section of a 100-ft long raised bed can hold approximately 24 to 30 gallons of water (Table 4). When drip irrigation is used, lateral water movement seldom exceeds 6 to 8 inches on each side of the drip tape (12 to 16 inches wetted width). When the volume of an irrigation exceeds the values in table 4, then irrigation should be split. Splitting will not only reduce nutrient leaching, it will also increase tomato quality by ensuring a more continuous water supply. Uneven water supply may result in fruit cracking.

Units for Measuring Irrigation Water. When overhead and seepage irrigation were the dominant methods of irrigation, acre-inches or vertical amounts of water were used as units for irrigations recommendations. There are 27,150 gallons in one acre-inch; thus, total volume was calculated by multiplying the recommendation expressed in acre-inch by 27,150. This unit reflected quite well the fact that the entire field was wetted.

Acre-inches are still used for drip irrigation, although the entire field is not wetted. This section is intended to clarify the conventions used in measuring water amounts for drip irrigation. In short, water amounts are handled similarly to fertilizer amounts, i.e., on an acre basis. When an irrigation amount expressed in acre-inch is recommended for plasticulture, it means that the recommended volume of water needs to be delivered to the row length present in a one-acre field planted at the standard bed spacing. So in this case, it is necessary to know the bed spacing to determine the exact amount of water to apply. In addition, drip tape flow rates are reported in gallons/hour/emitter or in gallons/hour/100 ft of row. Consequently, tomato growers tend to think in terms of multiples of 100 linear feet of bed, and ultimately convert irrigation amounts into duration of irrigation. It is important to correctly understand the units of the irrigation recommendation in order to implement it correctly.

Example. How long does an irrigation event need to last if a tomato grower needs to apply 0.20 acre-inch to a 2-acre tomato field. Rows are on 6-ft centers and a 12-ft spray alley is left unplanted every six rows? The drip tape flow rate is 0.30 gallons/hour/emitter and emitters are spaced 1 foot apart.

1. In the 2-acre field, there are 14,520 feet of bed (2 x 43,560/6). Because of the alleys, only 6/8 of the field is actually planted. So, the field actually contains 10,890 feet of bed (14,520x 6/8).

2. A 0.20 acre-inch irrigation corresponds to 5,430 gallons applied to 7,260 feet of row, which is equivalent to 75gallons/100feet (5,430/72.6).

3. The drip tape flow rate is 0.30 gallons/hr/emitter which is equivalent to 30 gallons/hr/100feet. It will take 1 hour to apply 30 gallons/100ft, 2 hours to apply 60gallons/100ft, and 2 ½ hours to apply 75 gallons. The total volume applied will be 8,168 gallons/2-acre (75 x 108.9).

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Table 1. Levels of water management and corresponding irrigation scheduling method for tomato

Water Management		
Level	**Rating**	**Irrigation scheduling method**
0	None	Guessing (irrigate whenever)
1	Very low	Using the 'feel and see' method
2	Low	Using systematic irrigation (example: 2 hrs every day)
3	Intermediate	Using a soil moisture measuring tool to start irrigation
4	Advanced	Using a soil moisture measuring tool to schedule irrigation and apply amounts based on a budgeting procedures
5	Recommended	Using together a water use estimate based on tomato plant stage of growth, a measurement of soil water moisture, and a guideline for splitting irrigation

Table 2. Crop coefficient estimates (Kc) for tomato[z].

Tomato Growth Stage	Plasticulture
1	0.30
2	0.40
3	0.90
4	0.90
5	0.75

[z] Actual values will vary with time of planting, length of growing season and other site-specific factors. Kc values should be used with ETo values in Table 2 to estimated crop evapotranspiration (ETc)

Table 3. Historical Penman-method reference ET (ETo) for four Florida locations (in gallons per acre per day)

Month	Tallahassee	Tampa	West Palm Beach	Miami
January	1,630	2,440	2,720	2,720
February	2,440	3,260	3,530	3,530
March	3,260	3,800	4,340	4,340
April	4,340	5,160	5,160	5,160
May	4,890	5,430	5,160	5,160
June	4,890	5,430	4,890	4,890
July	4,620	4,890	4,890	4,890
August	4,340	4,620	4,890	4,620
September	3,800	4,340	4,340	4,070
October	2,990	3,800	3,800	3,800
November	2,170	2,990	3,260	2,990
December	1,630	2,170	2,720	2,720

[z] assuming water application over the entire area with 100% efficiency

Table 4. Estimated maximum water application (in gallons per acre and in gallons/100lfb) in one irrigation event for tomato grown on 6-ft centers (7,260 linear bed feet per acre) on sandy soil (available water holding capacity 0.75 in/ ft and 50% soil water depletion). Split irrigations may be required during peak water requirement.

Wetting width (ft)	Gal/100ft to wet depth of 1 ft	Gal/100ft to wet depth of 1.5 ft	Gal/100ft to wet depth of 2 ft	Gal/acre to wet depth of 1 ft	Gal/acre to wet depth of 1.5ft	Gal/acre to wet depth of 2 ft
1.0	24	36	48	1,700	2,600	3,500
1.5	36	54	72	2,600	3,900	5,200

Fertilizer and Nutrient Management For Tomato

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Fertilizer and nutrient management are essential components of successful commercial tomato production. This article presents the basics of nutrient management for the different production systems used for tomato in Florida.

CALIBRATED SOIL TEST: TAKING THE GUESSWORK OUT OF FERTILIZATION

Prior to each cropping season, soil tests should be conducted to determine fertilizer needs and eventual pH adjustments. Obtain a UF/IFAS soil sample kit from the local agricultural Extension agent for this purpose. If a commercial soil testing laboratory is used, be sure the lab uses methodologies calibrated and extractants suitable for Florida soils. When used with the percent sufficiency philosophy, routine soil testing helps adjust fertilizer applications to plant needs and target yields. In addition, the use of routine calibrated soil tests reduces the risk of over-fertilization. Over fertilization reduces fertilizer efficiency and increases the risk of groundwater pollution. Systematic use of fertilizer without a soil test may also result in crop damage from salt injury.

The crop nutrient requirements of nitrogen, phosphorus, and potassium (designated in fertilizers as N-P_2O_5-K_2O) represent the optimum amounts of these nutrients needed for maximum tomato production (Table 1). Fertilizer rates are provided on a per-acre basis for tomato produced on 6-ft centers. Under these conditions, there are 7,260 linear feet of tomato row in an acre. When different row spacings are used or when a significant number of drive rows are left unplanted, it is necessary to adjust fertilizer application accordingly.

Fertilizer rates can be simply and accurately adjusted to row spacings other than the standard spacing (6-ft centers) by expressing the recommended rates on a 100 linear bed feet (lbf) basis, rather than on a real-estate acre basis. For example, in a 1-acre tomato field planted on 7-ft centers with one drive row every six rows, there are only 5,333 lbf (6/7 x 43,560 / 7). If the recommendation is to inject 10 lbs of N per acre (standard spacing), this becomes 10 lbs of N/7,260 lbf or 0.14lbs N/100 lbf. Since there are 5,333 lbf/acre in this example, then the adjusted rate for this situation is 7.46 lbs N/acre (0.14 x 53.33). In other words, an injection of 10 lbs of N to 7,260 lbf is accomplished by injecting 7.46 lbs of N to 5,333 lbf.

LIMING

The optimum pH range for tomatoes is 6.0 and 6.5. This is the range for which the availability of all the essential nutrients is highest. Fusarium wilt problems are reduced by liming within this range, but it is not advisable to raise the pH above 6.5 because of reduced micronutrient availability. In areas where soil pH is basic (>7.0), micronutrient deficiencies may be corrected by foliar sprays.

Calcium and magnesium levels should be corrected according to the soil test. If both elements are “low”, and lime is needed, then broadcast and incorporate dolomitic limestone. Where calcium alone is deficient, lime with “hi-cal” limestone. Adequate calcium is important for reducing the severity of blossom-end rot. Research shows that a Mehlich-I (double-acid) index of 300 to 350 ppm Ca would be indicative of adequate soil-Ca. On limestone soils, add 30-40 pounds per acre of magnesium in the basic fertilizer mix. It is best to apply lime several months prior to planting. However, if time is short, it is better to apply lime any time before planting than not to apply it at all. Where the pH does not need modification, but magnesium is low, apply magnesium sulfate or potassium-magnesium sulfate with the fertilizer.

Changes in soil pH may take several weeks to occur when carbonate-based liming materials are used (calcitic or dolomitic limestone). Oxide-based liming materials (quick lime -CaO- or dolomitic quick lime -CaO, MgO-) are fast reacting and rapidly increase soil pH. Yet, despite these advantages, oxide-based lime is more expensive than the traditional liming materials, and therefore are not routinely used.

The increase in pH induced by liming materials is NOT due to the presence of calcium or magnesium. Instead, it is the carbonate (“CO_3”) and oxide (“O”) part of $CaCO_3$ and ‘CaO’, respectively, that raises the pH. Through several chemical reactions that occur in the soil, carbonates and oxides release OH- ions that combine with H^+ to produce water. As large amounts of H^+ react, the pH rises. A large fraction of the Ca and/or Mg in the liming materials gets into solution and binds to the sites that are freed by H^+ that have reacted with OH-.

FERTILIZER-RELATED PHYSIOLOGICAL DISORDERS

Blossom-End Rot. Growers may have problems with blossom-end-rot, especially on the first or second fruit clusters. Blossom-end rot (BER) is a Ca deficiency in the fruit, but is often more related to plant water stress than to Ca concentrations in the soil. This is because Ca movement in the plant occurs with the water (transpiration) stream. Thus, Ca moves preferentially to the leaves. As a maturing fruit is not a transpiring organ, most of the Ca is deposited during early fruit growth.

Once BER symptoms develop on a tomato fruit, they cannot be alleviated on this fruit. Because of the physiological role of Ca in the middle lamella of cell walls, BER is a structural and irreversible disorder. Yet, the Ca nutrition of the plant can be altered so that the new fruits are not affected. BER is most effectively controlled by attention to irrigation and fertilization, or by using a calcium source such as calcium nitrate when soil Ca is low. Maintaining adequate and uniform amounts of moisture in the soil are also keys to reducing BER potential.

Factors that impair the ability of tomato plants to obtain water will increase the risk of BER. These factors include damaged roots from flooding, mechanical damage or nematodes, clogged drip emitters, inadequate water applications, alternating dry-wet periods, and even prolonged overcast periods. Other causes for BER include high fertilizer rates, especially potassium and nitrogen. High total fertilizer increases the salt content and osmotic potential in the soil reducing the ability of roots to obtain water, and high N increases leaf and shoot growth to which Ca preferentially moves, by-passing fruits.

Calcium levels in the soil should be adequate when the Mehlich-1 index is 300 to 350 ppm, or above. In these cases, added gypsum (calcium sulfate) is unlikely to reduce BER. Foliar sprays of Ca are unlikely to reduce BER because Ca does not move out of the leaves to the fruit.

Gray Wall. Blotchy ripening (also called gray wall) of tomatoes is characterized by white or yellow blotches that appear on the surface of ripening tomato fruits, while the tissue inside remains hard. The affected area is usually on the upper portion of the fruit. The etiology of this disorder has not been formally established, but it is often associated with high N and/or low K, and aggravated by excessive amount of N. This disorder may be at times confused with symptoms produced by the tobacco mosaic virus. Gray wall is cultivar specific and appears more frequently on older cultivars. The incidence of gray wall is less with drip irrigation where small amounts of nutrients are injected frequently, than with systems where all the fertilizer is applied pre-plant.

Micronutrients. For virgin, acidic sandy soils, or sandy soils where a proven need exists, a general guide for fertilization is the addition of micronutrients (in elemental lbs/A) manganese -3, copper -2, iron -5, zinc -2, boron -2, and molybdenum -0.02. Micronutrients may be supplied from oxides or sulfates. Growers using micronutrient-containing fungicides need to consider these sources when calculating fertilizer micronutrient needs. More information on micronutrient use is available from the suggested literature list.

Properly diagnosed micronutrient deficiencies can often be corrected by foliar applications of the specific micronutrient. For most micronutrients, a very fine line exists between sufficiency and toxicity. Foliar application of major nutrients (nitrogen, phosphorus, or potassium) has not been shown to be beneficial where proper soil fertility is present.

FERTILIZER APPLICATION

Mulch Production with Seepage Irrigation. Under this system, the crop may be supplied with all of its soil requirements before the mulch is applied (Table 1). It is difficult to correct a deficiency after mulch application, although a liquid fertilizer injection wheel can facilitate sidedressing through the mulch. The injection wheel will also be useful for replacing fertilizer under the used plastic mulch for double-cropping systems. A general sequence of operations for the full-bed plastic mulch system is:

1. Land preparation, including development of irrigation and drainage systems, and liming of the soil, if needed.

2. Application of "starter" fertilizer or "in-bed" mix. This should comprise only 10 to 20 percent of the total nitrogen and potassium seasonal requirements and all of the needed phosphorus and micronutrients. Starter fertilizer can be broadcast over the entire area prior to bedding and then incorporated. During bedding, the fertilizer will be gathered into the bed area. An alternative is to use a "modified broadcast" technique for systems with wide bed spacings. Use of modified broadcast or banding techniques can increase phosphorus and micronutrient efficiencies, especially on alkaline (basic) soils.

3. Formation of beds, incorporation of herbicide, and application of mole cricket bait.

4. Application of remaining fertilizer. The remaining 80 to 90 percent of the nitrogen and potassium is placed in narrow bands 9 to 10 inches to each side of the plant row in furrows. The fertilizer should be placed deep enough in the grooves for it to be in contact with moist bed soil. Bed presses are modified to provide the groove. Only water-soluble nutrient sources should be used for the banded fertilizer. A mixture of potassium nitrate (or potassium sulfate or potassium chloride), calcium nitrate, and ammonium nitrate has proven successful.

5. Fumigation, pressing of beds, and mulching. This should be done in one operation, if possible. Be sure that the mulching machine seals the edges of the mulch adequately with soil to prevent fumigant escape.

Water management with the seep irrigation system is critical to successful crops. Use water-table monitoring devices and/or tensiometers in the root zone to help provide an adequate water table but no higher than required for optimum moisture. It is recommended to limit fluctuations in water table depth since this can lead to increased leaching losses of plant nutrients.

Mulched Production with Drip Irrigation. Where drip irrigation is used, drip tape or tubes should be laid 1 to 2 inches below the bed soil surface prior to mulching. This placement helps protect tubes from mice and cricket damage. The drip system is an excellent tool with which to fertilize tomato. Where drip irrigation is used, apply all phosphorus and micronutrients, and 20 percent to 40 percent of total nitrogen and potassium preplant, prior to mulching. Apply the remaining nitrogen and potassium through the drip system in increments as the crop develops.

Successful crops have resulted where the total amounts of N and K_2O were applied through the drip system. Some growers find this method helpful where they have had problems with soluble-salt burn. This approach would be most likely to work on soils with relatively high organic matter and some residual potassium. However, it is important to begin with rather high rates of N and K_2O to ensure young transplants are established quickly. In most situations, some preplant N and K fertilizers are needed.

Suggested schedules for nutrient injections have been successful in both research and commercial situations, but might need slight modifications based on potassium soil-test indices and grower experience (Table 1).

SOURCES OF N-P_2O_5-K_2O.

About 30 to 50 percent of the total applied nitrogen should be in the nitrate form for soil treated with multi-purpose fumigants and for plantings in cool soil.

Controlled-release nitrogen sources may be used to supply a portion of the nitrogen requirement. One-third of the total required nitrogen can be supplied from sulfur-coated urea (SCU), isobutylidene diurea (IBDU), or polymer-coated urea (PCU) fertilizers incorporated in the bed. Nitrogen from natural organics and most controlled-release materials is initially in the ammoniacal form, but is rapidly converted into nitrate by soil microorganisms.

Normal superphosphate and triple superphosphate are recommended for phosphorus needs. Both contribute calcium and normal superphosphate contributes sulfur.

All sources of potassium can be used for tomatoes. Potassium sulfate, sodium-potassium nitrate, potassium nitrate, potassium chloride, monopotassium phosphate, and potassium-magnesium sulfate are all good K sources. If the soil test predicted amounts of K_2O are applied, then there should be no concern for the K source or its associated salt index.

SAP TESTING AND TISSUE ANALYSIS

While routine soil testing is essential in designing a fertilizer program, sap tests and/or tissue analyses reveal the actual nutritional status of the plant. Therefore these tools complement each other, rather than replace one another.

Analysis of tomato leaves for mineral nutrient content can help guide a fertilizer management program during the growing season or assist in diagnosis of a suspected nutrient deficiency. Tissue nutrient norms are presented in Table 2. Growers with drip irrigation can obtain faster analyses for N or K by using a plant sap quick test. Several kits have been calibrated for Florida tomatoes (Table 3).

For both nutrient monitoring tools, the quality and reliability of the measurements are directly related with the quality of the sample. A leaf sample should contain at least 20 most recently, fully developed, healthy leaves. Select representative plants, from representative areas in the field.

SUPPLEMENTAL FERTILIZER APPLICATIONS

In practice, supplemental fertilizer applications allow vegetable growers to numerically apply fertilizer rates higher than the standard UF/IFAS recommended rates when growing conditions require to do so. The two main growing conditions that may require supplemental fertilizer applications are leaching rains and extended harvest periods. Applying additional fertilizer under the three circumstances described in Table 1 is part of the current UF/IFAS fertilizer recommendations and nutrient BMPs.

Levels of Nutrient Management for Tomato Production

Based on the growing situation and the level of adoption of the tools and techniques described above, different levels of nutrient management exist for tomato production in Florida. Successful production requires management levels of 3 or above (Table 4).

SUGGESTED LITERATURE

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Table 1. Fertilization recommendations for tomato grown in Florida on sandy soils testing very low in Mehlich-1 potassium (K_2O).

		Recommended base fertilization[z]								Recommended supplemental fertilization[z]		
				Injected[x] (lbs/A/day) Weeks after transplanting[w]								
Production system	Nutrient	Total (lbs/A)	Preplant[y] (lbs/A)	1-2	3-4	5-11	12	13	Leaching rain[r,s]	Measured 'low' plant nutrient content[u,s]	Extended harvest season[s]
Drip irrigation, raised beds, and polyethylene mulch	N	200	0-70	1.5	2.0	2.5	2.0	1.5	n/a	1.5 to 2 lbs/ A/day for 7days[t]	1.5-2 lbs/ A/day[p]
	K_2O	220	0-70	2.5	2.0	3.0	2.0	1.5	n/a	1.5-2 lbs/ A/day for 7days[t]	1.5-2 lbs/ A/day[p]
Seepage irrigation, raised beds, and polyethylene mulch	N	200	200[v]	0	0	0	0	0	30 lbs/A[q]	30 lbs/A[t]	30 lbs/A[p]
	K_2O	220	220[v]	0	0	0	0	0	20 lbs/A[q]	20 lbs/A[t]	20 lbs/A[p]

[z] 1 A = 7,260 linear bed feet per acre (6-ft bed spacing); for soils testing 'very low' in Mehlich 1 potassium (K_2O).

[y] applied using the modified broadcast method (fertilizer is broadcast where the beds will be formed only, and not over the entire field). Preplant fertilizer cannot be applied to double/triple crops because of the plastic mulch; hence, in these cases, all the fertilizer has to be injected.

[x] This fertigation schedule is applicable when no N and K_2O are applied preplant. Reduce schedule proportionally to the amount of N and K_2O applied preplant. Fertilizer injections may be done daily or weekly. Inject fertilizer at the end of the irrigation event and allow enough time for proper flushing afterwards.

[w] For a standard 13 week-long, transplanted tomato crop grown in the Spring.

[v] Some of the fertilizer may be applied with a fertilizer wheel though the plastic mulch during the tomato crop when only part of the recommended base rate is applied preplant. Rate may be reduced when a controlled-release fertilizer source is used.

[u] Plant nutritional status may be determined with tissue analysis or fresh petiole-sap testing, or any other calibrated method. The 'low' diagnosis needs to be based on UF/IFAS interpretative thresholds.

[t] Plant nutritional status must be diagnosed every week to repeat supplemental application.

[s] Supplemental fertilizer applications are allowed when irrigation is scheduled following a recommended method. Supplemental fertilization is to be applied in addition to base fertilization when appropriate. Supplemental fertilization is not to be applied 'in advance' with the preplant fertilizer.

[r] A leaching rain is defined as a rainfall amount of 3 inches in 3 days or 4 inches in 7 days.

[q] Supplemental amount for each leaching rain

[p] Plant nutritional status must be diagnosed after each harvest before repeating supplemental fertilizer application.

Table 2. Deficient, adequate, and excessive nutrient concentrations for tomato [most-recently-matured (MRM) leaf (blade plus petiole)].

				N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo
				%						ppm					
Tomato	MRM[z] leaf	5-leaf stage	Deficient	<3.0	0.3	3.0	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate	3.0	0.3	3.0	1.0	0.3	0.3	40	30	25	20	5	0.2
			range	5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	0.6
			High	>5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	0.6
	MRM leaf	First flower	Deficient	<2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate	2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
			range	4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	0.6
			Toxic (>)								1500	300	250		
	MRM leaf	Early fruit set	Deficient	<2.5	0.2	2.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate	2.5	0.2	2.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			range	4.0	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
			Toxic (>)										250		
Tomato	MRM leaf	First ripe fruit	Deficient	<2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate	2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
			range	3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
			High	>3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
	MRM leaf	During harvest period	Deficient	<2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate	2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			range	3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6
			High	>3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6

[z]MRM=Most recently matured leaf.

Table 3. Recommended nitrate-N and K concentrations in fresh petiole sap for tomato.

	Sap concentration (ppm)	
Stage of growth	**NO_3-N**	**K**
First buds	1000-1200	3500-4000
First open flowers	600-800	3500-4000
Fruits one-inch diameter	400-600	3000-3500
Fruits two-inch diameter	400-600	3000-3500
First harvest	300-400	2500-3000
Second harvest	200-400	2000-2500

Table 4. Progressive levels of nutrient management for tomato production.[z]

Nutrient Management Level	Rating	Description
0	None	Guessing
1	Very low	Soil testing and still guessing
2	Low	Soil testing and implementing 'a' recommendation
3	Intermediate	Soil testing, understanding IFAS recommendations, and correctly implementing them
4	Advanced	Soil testing, understanding IFAS recommendations, correctly implementing them, and monitoring crop nutritional status
5	Recommended	Soil testing, understanding IFAS recommendations, correctly implementing them, monitoring crop nutritional status, and practice year-round nutrient management and/or following BMPs (including one of the recommended irrigation scheduling methods).

[z] These levels should be used together with the highest possible level of irrigation management

Fungicides and Other Products for the Management of Tomato Diseases in Florida (Updated July 1, 2005)

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Be sure to read a current product label before applying any chemical.

Chemical	FRAC Code[1]	Maximum Rate / Acre / Applic.	Maximum Rate / Acre / Season	Min. Days to Harvest	Pertinent Diseases or Pathogens	Remarks[2]
Manex 4 F	M3	2.4 qts.	16.8 qts.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label
Dithane, Manzate or Penncozeb 75 DFs	M3	3 lbs.	22.4 lbs.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label
Maneb 80 WP	M3	3 lbs	21 lbs.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label
Dithane F 45 or Manex II 4 FLs	M3	2.4 pts.	16.8 qts.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label
Dithane M-45, Penncozeb 80, or Manzate 80 WPs	M3	3 lbs.	21 lbs.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label
Maneb 75 DF	M3	3 lbs.	22.4 lbs.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label
Equus 7204, Echo 720, Chloro Gold 720 6 Fls	M5	3 pts. or 2.88 pts.	20.1 pts.	2	Early blight Late blight Gray leaf spot Target spot	Use higher rates at fruit set and lower rates before fruit set, see label
Echo 90 DF or Equus 82.5DF	M5	2.3 lbs.		2	Early blight Late blight Gray leaf spot Target spot	Use higher rates at fruit set and lower rates before fruit set, see label
Ridomil Gold Bravo 76.4 W	4 / M5	3 lbs.	12 lbs	14	Early blight Late blight	Limit is 4 appl./crop, see label
Amistar 80 DF	11	2 ozs	12 ozs	0	Gray leaf spot Target Spot Early blight Late blight Sclerotinia Powdery mildew Target spot Buckeye rot	Limit is 2 seqential appl. or 6 application total. Alternate or tank mix with a multi-site effective fungicide (FRAC code M), see label

Chemical	FRAC Code[1]	Maximum Rate / Acre / Applic.	Maximum Rate / Acre / Season	Min. Days to Harvest	Pertinent Diseases or Pathogens	Remarks[2]
Quadris	11	6.2 fl.ozs.	37.2 fl.ozs.	0	Gray leaf spot Target Spot Early blight Late blight Sclerotinia Powdery mildew Target spot Buckeye rot	Limit is 2 seqential appl. or 6 application total. Alternate or tank mix with a multi-site effective fungicide (FRAC code M), see label
Cabrio 2.09 F	11	16 fl oz	96 fl oz	0	Gray leaf spot Target Spot Early blight Late blight Sclerotinia Powdery mildew Target spot Buckeye rot	Limit is 2 seqential appl. or 6 application total. Alternate or tank mix with a multi-site effective fungicide (FRAC code M), see label
Flint	11		16 oz	3	Early blight Late blight Gray leaf spot	See label for details
Ridomil Gold EC	4	2 pts. / trtd. acre	3 pts / trtd / acre	28	Pythium diseases	See label for details
Ridomil MZ 68 WP	4 / M3	2.5 lbs.	7.5 lbs.	5	Late blight	Limit is 3 appl./crop, see label
Ridomil Gold Copper 64.8 W	4 / M1	2 lbs.		14	Late blight	Limit is 3 appl. /crop. Tank mix with maneb or mancozeb fungicide, see label
JMS Stylet-Oil		3 qts.			Potato Virus Y Tobacco Etch Virus CMV	See label for restrictions and use (e.g. use of 400 psi spray pressure)
Aliette 80 WDG	33	5 lbs.	20 lbs.	14	Phytophthora root rot	Using potassium carbonate or Diammonium phosphate, the spray of Aliette should be raised to a pH of 6.0 or above when applied prior to or after copper fungicides, see label
Bravo Ultrex	M5	2.6 lbs.	18.3 lbs	2	Early blight Late blight Gray leaf spot Target spot Botrytis Rhizoctonia fruit rot	Use higher rates at fruit set, see label
Bravo Weather Stik	M5	2 ¾ pts.	20 pts	2	Early blight Late blight Gray leaf spot Target spot Botrytis Rhizoctonia fruit rot	Use higher rates at fruit set, see label
Botran 75 W	14	1 lb.	4 lbs.	10	Botrytis	Greenhouse use only. Limit is 4 applications. Seedlings or newly set transplants may be injured, see label
Nova 40 W	3	4 ozs.	1.25 lbs.	0	Powdery mildew	Note that a 30 day plant back restriction exists, see label

Chemical	FRAC Code[1]	Maximum Rate / Acre / Applic.	Maximum Rate / Acre / Season	Min. Days to Harvest	Pertinent Diseases or Pathogens	Remarks[2]
Sulfur (many brands)	M2			1	Powdery mildew	Follow label closely, it may cause phytotoxicity.
Actigard	P	1/3-3/4 oz.	4 ozs.	14	Bacterial spot Bacterial speck Tomato spotted wilt – a viral disease (use in combination of UV-reflective mulch and vector thrips specific insecticides.	Do not use highest labeled rate in early sprays to avoid a delayed onset of harvest. See label for details.
ManKocide 61.1 DF	M3 / M1	5 lbs.	112 lbs.	5	Bacterial spot Bacterial speck Late blight Early blight Gray leaf spot	See label
Gavel 75DF	M3 / 22	2.0 lbs	16 lbs	5	Buckeye rot Early blight Gray leaf spot Late blight Leaf mold	See label
Previcur Flex	28	0.7-1.5 pints (see Label)	7.5 pints	5	Late blight	Only in a tank mixture with chlorotalonil, maneb or mancozeb, see label
Curzate 60DF	27	5 oz	30 oz per 12 month	3	Late Blight	Do not use alone, see label for details
Tanos	11 / 27	8 oz	72 oz	3	Early blight Late blight Target spot Bacterial spot (suppression)	See label for details
Acrobat 50 WP	15	6.4 oz	32 oz	4	Late blight	See label for details
K-phite (Phosphorous acid)	33	2 qts. in a minimum of 100 gal.		0	*Phythophthora* sp. (root rot) *Pythium* sp. (Damping-off)	Dosage given is for drip application. See label for restrictions and details
Scala SC	9	7 fl oz 0.27 lbs	35 fl oz 1.4 lbs	1	Early blight Botrytis	Use only in a tank mix with another effective fungicide (non FRAC code 9), see label
Endura	7	3.5 oz		0	Target spot	Alternate with non-FRAC code 7 fungicides, see label
Terraclor 75 WP	14	See Label	See Label	Soil treat-ment at planting	Southern blight (*Sclerotium rolfsii*)	See label for application type and restrictions
Fix Copper +mancozeb or maneb	M1 / M3			5	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Kocide 101 or Champion 77 WPs	M1	4 lbs.		2	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Kocide 4.5 LF	M1	2 2/3 pts		1	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label

Chemical	FRAC Code[1]	Maximum Rate / Acre / Applic.	Season	Min. Days to Harvest	Pertinent Diseases or Pathogens	Remarks[2]
Kocide 2000 53.8 DF	M1	3 lbs.		1	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Champ 57.6 DP	M1	1 1/3 lbs		1	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Basicop 53 WP	M1	4 lbs.		1	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Kocide 61.4 DF	M1	4 lbs			Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Cuprofix Disperss 36.9 DF	M1	6 lbs			Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds, see label
Allpro Exotherm Termil (20 % chlorothalonil)	M5	1 can / 1000 sq. ft.		7	Botrytis Leaf mold Late blight Early blight Gray leaf spot Target spot	Greenhouse use only. Allow can to remain overnight and then ventilate. Do not use when greenhouse temperature is above 75 F, see label

[1] FRAC code (fungicide group): Numbers (1-37) and letters (M, U, P) are used to distinguish the fungicide mode of action groups. All fungicides within the same group (with same number or letter) indicate same active ingredient or similar mode of action. This information must be considered for the fungicide resistance management decisions. M = Multi site inhibitors, fungicide resistance risk is low; U = Recent molecules with unknown mode of action; P = host plant defense inducers. Source: http://www.frac.info/ (FRAC = Fungicide Resistance Action Committee)

[2] Information provided in this table applies only to Florida. Be sure to read a current product label before applying any chemical. The use of brand names and any mention or listing of commercial products or services in the publication does not imply endorsement by the University of Florida Cooperative Extension Service nor discrimination against similar products or services not mentioned.

[3] Tank mix of mancozeb or maneb enhances bactericidal effect of copper compounds.

Selected Insecticides Approved for Use on Insects Attacking Tomatoes

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Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
Acramite-50WS (bifenazate)	0.75-1.0 lb	12	3	twospotted spider mite	2	One application per season.
Admire 2F (imidacloprid)	16-24 fl oz	12	21	aphids, Colorado potato beetle, flea beetles, leafhoppers, thrips (foliar feeding thrips only), whiteflies	4A	Most effective if applied to soil at transplanting. Limited to 24 oz/acre.
Admire 2F (imidacloprid)	1.4 fl oz/1000 plants	12	0 (soil)	aphids, whiteflies	4A	Greenhouse Use: 1 application to mature plants, see label for cautions.
Admire 2F (imidacloprid)	0.1 fl oz/1000 plants	12	21	aphids, whiteflies	4A	Planthouse: 1 application. See label.
Agree WG (*Bacillus thuringiensis* subspecies *aizawai*)	0.5-2.0 lb	4	0	lepidopteran larvae (caterpillar pests)	11B1	Apply when larvae are small for best control. Can be used in greenhouse. OMRI-listed[2].
***Agri-Mek 0.15EC** (abamectin)	8-16 fl oz	12	7	Colorado potato beetle, *Liriomyza* leafminers, spider mite, tomato pinworms, tomato russet mite	6	Do not make more than 2 sequential applications. Do not apply more than 48 fl oz per acre per season.
***Ambush 25W** (permethrin)	3.2-12.8 oz	12	up to day of harvest	beet armyworm, cabbage looper, Colorado potato beetle, granulate cutworms, hornworms, southern armyworm, tomato fruitworm, tomato pinworm, vegetable leafminer	3	**Do not use on cherry tomatoes.** Do not apply more than 1.2 lb ai/acre per season (76.8 oz). Not recommended for control of vegetable leafminer in Florida.
***Asana XL (0.66EC)** (esfenvalerate)	2.9-9.6 fl oz	12	1	beet armyworm (aids in control), cabbage looper, Colorado potato beetle, cutworms, flea beetles, grasshoppers, hornworms, potato aphid, southern armyworm, tomato fruitworm, tomato pinworm, whiteflies, yellowstriped armyworm	3	Not recommended for control of vegetable leafminer in Florida. Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
Assail 70WP (acetamiprid)	0.6-1.7 oz	12	7	aphids, Colorado potato beetle, thrips, whiteflies	4A	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Begin applications for whiteflies when first adults are noticed. Do not apply more than 4 times per season or apply more often than every 7 days.
Avaunt (indoxacarb)	2.5-3.5 oz	12	3	beet armyworm, hornworms, loopers, southern armyworm, tomato fruitworm, tomato pinworm, suppression of leafminers	22	Do not apply more than 14 ounces of product per acre per crop. Minimum spray interval is 5 days.
Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed	4	0	aphids, beetles, caterpillars, leafhoppers, leafminers, mites, stink bugs, thrips, weevils, whiteflies	26	Antifeedant, repellant, insect growth regulator. OMRI-listed[2].
Azatin XL (azadirachtin)	5-21 fl oz	4	0	aphids, beetles, caterpillars, leafhoppers, leafminers, mites, stink bugs, thrips, weevils, whiteflies	26	Antifeedant, repellant, insect growth regulator.
***Baythroid 2** (cyfluthrin)	1.6-2.8 fl oz	12	0	beet armyworm(1), cabbage looper, Colorado potato beetle, dipterous leafminers, European corn borer, flea beetles, hornworms, potato aphid, southern armyworm(1), stink bugs, tomato fruitworm, tomato pinworm, variegated cutworm , western flower thrips, whitefly(2)	3	(1) Ist and 2nd instars only (2) suppression Do not apply more than 0.26 lb ai per acre per season. Maximum number of applications: 6.
Biobit HP (*Bacillus thuringiensis* subspecies *kurstaki*)	0.5-2.0 lb	4	0	caterpillars (will not control large armyworms)	11B2	Treat when larvae are young. Good coverage is essential. Can be used in the greenhouse. OMRI-listed[2].
BotaniGard 22 WP, ES (*Beauveria bassiana*)	**WP:** 0.5-2 lb/100 gal **ES:** 0.5-2 qts 100/ gal	4	0	aphids, thrips, whiteflies	--	May be used in greenhouses. Contact dealer for recommendations if an adjuvant must be used. Not compatible in tank mix with fungicides.
***Capture 2EC** (bifenthrin)	2.1-5.2 fl oz	12	1	aphids, armyworms, corn earworm, cutworms, flea beetles, grasshoppers, mites, stink bug spp., tarnished plant bug, thrips, whiteflies	3	Make no more than 4 applications per season. Do not make applications less than 10 days apart.

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
CheckMate TPW, TPW-F (pheromone)	**TPW:** 200 dispenser **TPW-F:** 1.2-6.0 fl oz	0	0	tomato pinworm	--	For mating disruption - See label. TPW formulation. OMRI-listed[2].
Condor (*Bacillus thuringiensis* subspecies *kurstaki*)	0.67-1.67 qts	4	0	caterpillars	11B2	Do not use in combination with any chlorothalonil-based fungicides. Use caution when mixing with other oil-based products or surfactants. Treat when larvae are young. Good coverage is essential.
Confirm 2F (tebufenozide)	6-16 fl oz	4	7	armyworms, black cutworm, hornworms, loopers	18	Product is a slow-acting IGR that will not kill larvae immediately. Do not apply more than 1.0 lb ai per acre per season.
Courier 70WP, 40SC (buprofezin)	**70WP:** 6-9 oz **40SC:** 9-13.6 fl oz	12	7	whitefly nymphs	16	See label for plantback restrictions. Apply when a threshold is reached of 5 nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. No more than 2 applications per season. Allow at least 28 days between applications.
Crymax WDG (*Bacillus thuringiensis* subspecies *kurstaki*)	0.5-2.0 lb	4	0	caterpillars	11B2	Use high rate for armyworms. Treat when larvae are young.
***Danitol 2.4 EC** (fenpropathrin)	10.67 fl oz	24	3 days, or 7 if mixed with Monitor 4	beet armyworm, cabbage looper, fruitworms, potato aphid, silverleaf whitefly, stink bugs, thrips, tomato pinworm, twospotted spider mites, yellowstriped armyworm	3	Use alone for control of fruitworms, stink bugs, twospotted spider mites, and yellowstriped armyworms. Tank-mix with Monitor 4 for all others, especially whitefly. Do not apply more than 0.8 lb ai per acre per season. Do not tank mix with copper.
Deliver (*Bacillus thuringiensis* subspecies *kurstaki*)	0.25-1.5 lb	4	0	caterpillars	11B2	Use higher rates for armyworms. OMRI-listed[2].

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
***Diazinon AG500; 4E; *50 W** (diazinon)	**AG500, 4E:** 0.5-1.5 pts **50W:** 0.5-1.5 lb	24	1	aphids, beet armyworm, banded cucumber beetle, *Drosophila*, fall armyworm, dipterous leafminers, southern armyworm	1B	Will not control organophosphate-resistant leafminers. Do not apply more than five times per season.
	AG500, 4E: 1-4 qts **50W:** 2-8 lb	24	preplant	cutworms, mole crickets, wireworms		
Dimethoate 4 EC, 2.67 EC (dimethoate)	**4EC:** 0.5-1.0 pt **2.67:** 0.75-1.5 pt	48	7	aphids, leafhoppers, leafminers	1B	Will not control organophosphate-resistant leafminers.
DiPel DF (*Bacillus thuringiensis* supspecies *kurstaki*)	0.5-2.0 lb	4	0	caterpillars	11B2	Treat when larvae are young. Good coverage is essential. OMRI-listed[2].
Endosulfan 3EC (endosulfan)	0.66-1.33 qt	24	2	aphids, blister beetle, cabbage looper, Colorado potato beetle, flea beetles, hornworms, stink bugs, tomato fruitworm, tomato russet mite, whiteflies, yellowstriped armyworm	2	Do not exceed a maximum of 3.0 lb active ingredient per acre per year or apply more than 6 times. Can be used in greenhouse.
Entrust (spinosad)	0.5-2.5 oz	4	1	armyworms, Colorado potato beetle, flower thrips, hornworms, *Liriomyza* leafminers, loopers, other caterpillars, tomato fruitworm, tomato pinworm	5	Do not apply more than 9 oz per acre per crop. OMRI-listed[2].
Esteem Ant Bait (pyriproxyfen)	1.5-2.0 lb	12	1	red imported fire ant	7C	Apply when ants are actively foraging.
Extinguish ((S)-methoprene)	1.0-1.5 lb	4	0	fire ants	7A	Slow-acting IGR (insect growth regulator). Best applied early spring and fall where crop will be grown. Colonies will be reduced after three weeks and eliminated after 8 to 10 weeks. May be applied by ground equipment or aerially.
Fulfill (pymetrozine)	2.75 oz	12	0 - if 2 applications 14 - if 3 or 4 applications	green peach aphid, potato aphid, suppression of whiteflies	9B	Do not make more than four applications. 24(c) label for growing transplants also.
Intrepid 2F (methoxyfenozide)	4-16 fl oz	4	1	beet armyworm, cabbage looper, fall armyworm, hornworms, southern armyworm, tomato fruitworm, true armyworm, yellowstriped armyworm	18	Do not apply more than 64 fl oz acre per season. Product is a slow-acting IGR that will not kill larvae immediately.

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
Javelin WG (*Bacillus thuringiensis* subspecies *kurstaki*)	0.12-1.5 lb	4	0	most caterpillars, but not *Spodoptera* species (armyworms)	11B2	Treat when larvae are young. Thorough coverage is essential. OMRI-listed[2].
Kelthane MF 4 (dicofol)	0.75-1.5 pt	12	2	tomato russet mites, twospotted and other spider mites	20	Do not apply more than twice a season or more than 1.6 pts per year.
Knack IGR (pyriproxyfen)	8-10 fl oz	12	14	immature whiteflies	7C	Apply when a threshold is reached of 5 nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. Make no more than two applications per season.
Kryocide; (cryolite)	8-16 lb	12	14	blister beetle, cabbage looper, Colorado potato beetle larvae, flea beetles, hornworms, tomato fruitworm, tomato pinworm	9A	Minimum of 7 days between applications. Do not apply more than 64 lbs per acre per season. Not for cherry tomatoes.
***Lannate LV, *SP** (methomyl)	**LV:** 0.75-3.0 pt **SP:** 0.25-1.0 lb	48	1	aphids, armyworms, beet armyworm, fall armyworm, hornworms, loopers, southern armyworm, tomato fruitworm, tomato pinworm, variegated cutworm	1A	Do not apply more than 6.3 lb ai/acre per crop.
Lepinox WDG (*Bacillus thuringiensis* subspecies *kurstaki*)	1.0-2.0 lb	12	0	for most caterpillars, including beet armyworm (see label)	11B2	Treat when larvae are small. Thorough coverage is essential.
Malathion 8 F (malathion)	1.5-2 pt	12	1	aphids, *Drosophila*, mites	1B	Can be used in greenhouse.
***Monitor 4EC** (methamidophos) [24(c) labels]	1.5-2 pts	48	7	thrips (North Florida only), whiteflies(1)	1B	(1) Use as tank mix with a pyrethroid for whitefly control. Do not apply more than 10 pts per acre, or 18 pts per acre in North Florida per season.
M-Pede 49% EC (Soap, insecticidal)	1-2% V/V	12	0	aphids, leafhoppers, mites, plant bugs, thrips, whiteflies	--	OMRI-listed[2].

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
***Mustang Max** (zeta-cypermethrin)	2.24-4.0 oz	12	1	beet armyworm, cabbage looper, Colorado potato beetle, cutworms, fall armyworm, flea beetles, grasshoppers, green and brown stink bugs. hornworms, leafminers, leafhoppers, *Lygus* bugs, plant bugs, southern armyworm, tobacco budworm, tomato fruitworm, tomato pinworm, true armyworm, yellowstriped armyworm. Aides in control of aphids, thrips and whiteflies.	3	Not recommended for vegetable leafminer in Florida. Do not make applications less than 7 days apart. Do not apply more than 0.3 lb ai per acre per season.
Neemix 4.5 (azadirachtin)	4-16 fl oz	12	0	aphids, armyworms, hornworms, psyllids, Colorado potato beetle, cutworms, leafminers, loopers, tomato fruitworm (corn earworm), tomato pinworm, whiteflies	18A	IGR, feeding repellant. OMRI-listed[2].
NoMate MEC TPW (pheromone)		0	0	tomato pinworm	--	For mating disruption - See label.
Oberon 2SC (spiromesifen)	7.0-8.5 fl oz	12	7	twospotted spider mite, whiteflies (eggs and mymphs)	23	Maximum amount per crop: 25.5 fl oz/ acre. No more than 3 applications.
Platinum (thiamethoxam)	5-8 fl oz	12	30	aphids, Colorado potato beetles, flea beetles, whiteflies	4A	Soil application. See label for rotational restrictions.
***Pounce 3.2 EC** (permethrin)	2-8 oz	12	0	beet armyworm, cabbage looper, Colorado potato beetle, dipterous leafminers, granulate cutworm, hornworms, southern armyworm, tomato fruitworm, tomato pinworm	3	Do not apply to cherry or grape tomatoes (fruit less than 1 inch in diameter). Do not apply more than 1.2 lb ai per acre per season.
***Proaxis Insecticide** (gamma-cyhalothrin)	1.92-3.84 fl oz	24	5	aphids(1), beet armyworm(2), blister beetles, cabbage looper, Colorado potato beetle, cucumber beetles (adults), cutworms, hornworms, fall armyworm(2), flea beetles, grasshoppers, leafhoppers, plant bugs, southern armyworm(2), spider mites(1), stink bugs, thrips(1), tobacco budworm, tomato fruitworm, tomato pinworm, vegetable weevil (adult), whiteflies(1), yellowstriped armyworm(2)	3	(1) Suppression only. (2) First and second instars only. Do not apply more than 2.88 pints per acre per season.

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
***Proclaim** (emamectin benzoate)	2.4-4.8 oz	48	7	beet armyworm, cabbage looper, fall armyworm, hornworms, southern armyworm, tobacco budworm, tomato fruitworm, tomato pinworm, yellowstriped armyworm	6	No more than 28.8 oz/ acre per season.
Prokil Cryolite 96 (cryolite)	10-16 lb	12	14	blister beetle, cabbage looper, Colorado potato beetle larvae, flea beetles, hornworms, tomato fruitworm, tomato pinworm	9A	Minimum of 7 days between applications. Do not apply more than 64 lbs per acre per season. Not for cherry tomatoes.
Provado 1.6F (imidacloprid)	3.8 oz	12	0	aphids, Colorado potato beetle, leafhoppers, whiteflies	4A	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Do not apply more than 18.75 oz per acre as foliar spray.
Pyrellin EC (pyrethrin + rotenone)	1-2 pt	12	12 hours	aphids, Colorado potato beetle, cucumber beetles, flea beetles, flea hoppers, leafhoppers, leafminers, loopers, mites, plant bugs, stink bugs, thrips, vegetable weevil, whiteflies	3, 21	
Sevin 80S; XLR; 4F (carbaryl)	**80S:** 0.63-2.5 **XLR; 4F:** 0.5-2.0 A	12	3	Colorado potato beetle, cutworms, fall armyworm, flea beetles, lace bugs, leafhoppers, plant bugs, stink bugs(1), thrips(1), tomato fruitworm, tomato hornworm, tomato pinworm, sowbugs	1A	(1) suppression Do not apply more than seven times. Do not apply a total of more than 10 lb or 8 qt per acre per crop.
SpinTor 2SC (spinosad)	1.5-8.0 fl oz	4	1	armyworms, Colorado potato beetle, flower thrips, hornworms, *Liriomyza* leafminers, loopers, *Thrips palmi*, tomato fruitworm, tomato pinworm	5	Do not apply to seedlings grown for transplant within a greenhouse or shadehouse. Leafminer and thrips control may be improved by adding an adjuvant. Do not apply more than three times in any 21 day period. Do not apply more than 29 ozs per acre per crop.

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
Spod-X LC (beet armyworm nuclear polyhedrosis virus)	1.7-3.4 fl oz	4	0	beet armyworm	--	Treat when larvae are small (1st and 2nd instar). Follow label instructions for mixing. Use only non-chlorinated water at a pH near 7 for mixing. OMRI-listed[2].
Sulfur (many brands)	See label	24	see label	tomato russet mite	--	
***Telone C-35** (dichloropropene + chloropicrin)	See label	5 days (See label)	preplant	garden centipedes (symphylans), wireworms	--	See supplemental label for restrictions in certain Florida counties.
Trigard (cyromazine)	26.6 oz	12	0	Colorado potato beetle (suppression of), leafminers	17	No more than 6 applications per crop.
Trilogy (extract of neem oil)	0.5-2.0% V/V	4	0	aphids, mites, suppression of thrips and whiteflies	26	Apply morning or evening to reduce potential for leaf burn. Toxic to bees exposed to direct treatment. OMRI-listed[2].
Ultra Fine Oil, JMS Stylet-Oil, and others (oil, insecticidal)	3-6 qts/100 gal (JMS)	4	0	aphids, beetle larvae, leafhoppers, leafminers, mites, thrips, whiteflies, aphid-transmitted viruses (JMS)	--	Do not exceed four applications per season. Organic Stylet-Oil is OMRI-listed[2].
Venom 20SG (dinotefuran)	foliar: 0.44-0.895 lb soil: 1.13-1.34 lb	12	foliar: 1 soil: 21	Colorado potato beetle, green peach aphid, flea beetles, leahoppers, leafminers, potato aphid thrips, whiteflies	4A	Use only one application method (soil or foliar) do not apply more than 1.34 lb/acre (foliar) or 2.68 lb/acre (soil) per crop season.
***Vydate L 2EC** (oxamyl)	Foliar: 2-4 pt	48	3	aphids, Colorado potato beetle, leafminers (except *Liriomyza trifolii*), whiteflies (suppression only)	1A	Do not apply more than 32 pts per acre per season.
***Warrior** (lambda-cyhalothrin)	1.92-3.84 fl oz	24	5	aphids(1), beet armyworm(2), cabbage looper, Colorado potato beetle, cutworms, fall armyworm(2), flea beetles, grasshoppers, hornworms, leafhoppers, leafminers(1), plant bugs, southern armyworm(2), stink bugs, thrips(3), tomato fruitworm, tomato pinworm, whiteflies(1), yellowstriped armyworm(2)	3	(1) suppression only (2) for control of 1st and 2nd instars only. Do not apply more than 0.36 lb ai per acre per season. (3)Does not control western flower thrips.

Trade Name (Common Name)	Rate (product/acre)	REI (hours)	Days to Harvest	Insects	MOA Code[1]	Notes
Xentari DF (*Bacillus thuringiensis* subspecies *aizawai*)	0.5-2 lb	4	0	caterpillars	11B1	Treat when larvae are young. Thorough coverage is essential. May be used in the greenhouse. Can be used in organic production. OMRI-listed[2].

The pesticide information presented in this table was current with federal and state regulations at the time of revision. The user is responsible for determining the intended use is consistent with the label of the product being used. Use pesticides safely. Read and follow label instructions.

[1] Mode of Action codes for vegetable pest insecticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification v.3.3 October 2003.

1A. Acetylcholine esterase inhibitors, Carbamates
1B. Acetylcholine esterase inhibitors, Organophosphates
2A. GABA-gated chloride channel antagonists
3. Sodium channel modulators
4A. Nicotinic Acetylcholine receptor agonists/antagonists, Neonicotinoids
5. Nicotinic Acetylcholine receptor agonists (not group 4)
6. Chloride channel activators
7A. Juvenile hormone mimics, Juvenile hormone analogues
7C. Juvenile hormone mimics, Pyriproxifen
9A. Compounds of unknown or non-specific mode of action (selective feeding blockers), Cryolite
9B. Compounds of unknown or non-specific mode of action (selective feeding blockers), Pymetrozine
11B1. Microbial disruptors of insect midgut membranes, *B.t.* var *aizawai*
11B2. Microbial disruptors of insect midgut membranes, *B.t.* var *kurstaki*
12B. Inhibitors of oxidative phosphorylation, disruptors of ATP formation, Organotin miticide
15. Inhibitors of chitin biosynthesis, type 0, Lepidopteran
16. Inhibitors of chitin biosynthesis, type 1, Homopteran
17. Inhibitors of chitin biosynthesis, type 2, Dipteran
18. Ecdysone agonist/disruptor
20. Site II electron transport inhibitors
21. Site I electron transport inhibitors
22. Voltage-dependent sodium channel blocker
23. Inhibitors of lipid biosynthesis
25. Neuroactive (unknown mode of action)
26. Unknown mode of action, Azadirachtin

[2] OMRI listed: Listed by the Organic Materials Review Institute for use in organic production.

* Restricted Use Only

Insects Currently Used on Vegetables[1]

S. E. Webb and P. A. Stansly[2]

The following table lists many of the common insecticides currently labeled for use on vegetables in Florida. A number of new materials have been registered in the past few years or have had additional crops added to their labels. Some older organophosphate insecticides (methyl parathion, in particular) are now restricted to just a few crops, a result of recent rulings related to the Food Quality Protection Act. Changes continue, thus this listing may not be totally accurate at the time of printing.

No attempt has been made to list all available formulations. Some are listed under "Signal Word," when different formulations differ in toxicity. Many of the listed insecticides are limited to specific vegetables. Specific crop recommendations and pesticide labels should be consulted for more detailed information.

Insects can become resistant to any insecticide if it is used repeatedly. This also applies to alternating insecticides with similar modes of action, for example following a soil application of Admire with foliar applications of Actara or Assail (all neonicotinoids). To complicate matters, some insecticides in the same class have different modes of action and some unrelated chemicals have the same mode of action. In general, pesticides with the same mode of action s hould be used no more than twice in any crop cycle if residual activity is short and only once if residual activity is long. To aid in developing a spray program we have included a column with a code number for the mode of action of each insecticide. A footnote lists the mode of action associated with the code. In addition to alternating insecticides with different modes of action, integrating other non-chemical control measures in a pest management program should help to delay resistance.

1 This document is ENY-419, one of a series of the Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Revised: July 2005. Please visit the EDIS Website at http://edis.ifas.ufl.edu.

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Table 1. Insecticides For Use On Vegetables

Insecticide	General Characteristics	Signal Word	MOA[1]	Typical Target Pests
		Organophosphates		
*Counter (terbufos)	systemic action	Danger-Poison	1B	soil pests
*Diazinon		Caution	1B	aphids, beetles, caterpillars, soil pests, thrips
Dibrom (naled)	some short residual fumigant action	Danger	1B	caterpillars
Dimethoate	local systemic	Warning	1B	aphids, leafhoppers, mites
*Di-Syston (disulfoton)	systemic action	Danger-Poison	1B	aphids
*Guthion (azinphosmethyl)		Danger-Poison	1B	beetles, caterpillars, maggots
Imidan (phosmet)		Warning	1B	caterpillars, sweetpotato weevil
Lorsban (chlorpyrifos)	long residual	Caution - (15G) Warning - (50W, *4E)	1B	caterpillars, soil pests
Malathion	short residual	Warning	1B	broad spectrum
*MSR Spray Concentrate (oxydemetonmethyl)	systemic; contact & stomach action	Warning	1B	aphids, thrips & other sucking insects
*Mocap (ethoprop)	contact action	Warning - (10G, *15G)	1B	aphids, caterpillars
*Monitor (methamidophos)	long residual	Danger-Poison	1B	aphids, caterpillars & other pests
Orthene (acephate)	contact action & local systemic action	Caution	1B	aphids, caterpillars
*Penncap-M (methyl parathion)	contact & fumigant action; slow release formulation	Warning - (Penncap-M only)	1B	caterpillars, thrips
*Thimet (phorate)	systemic action	Danger-Poison	1B	soil pests
Carbamates				
*Furadan (carbofuran)	systemic action	Danger-Poison	1A	beetles, some caterpillars
*Lannate (methomyl)	very short residual	Danger-Poison	1A	caterpillars, leafhoppers
Larvin (thiodicarb)	larvicide & ovicide	Warning	1A	caterpillars
Sevin (carbaryl)	use can result in aphid and mite outbreaks	Caution - (4F, XLR, Bait) Warning - (80S)	1A	beetles, leafhoppers, caterpillars
*Temik (aldicarb)	systemic action	Danger-Poison	1A	aphids, mites, some beetles
*Vydate (oxamyl)	contact action, systemic if applied to soil	Danger-Poison	1A	aphids, thrips, some beetles
Organochlorines				
Endosulfan (endosulfan)	fairly long residual	Danger-Poison	2A	aphids, beetles, caterpillars, whiteflies
Kelthane (dicofol)		Caution - (MF) Warning - (35)	20	spider mites, broad mites

Insecticide	General Characteristics	Signal Word	MOA[1]	Typical Target Pests
		Pyrethroids		
*Ambush (permethrin)		Warning	3	beetles, caterpillars, leafhoppers, thrips
*Ammo (cypermethrin)		Caution	3	beetles, caterpillars, leafhoppers, thrips
*Asana (esfenvalerate)		Warning	3	beetles, caterpillars, leafhoppers
*Baythroid (cyfluthrin)		Danger	3	beetles, caterpillars, leafhoppers, thrips
*Capture, Brigade (bifenthrin)		Warning	3	beetles, caterpillars, leafhoppers, thrips, whiteflies
*Danitol (fenpropathrin)		Danger	3	caterpillars, leafhoppers, whiteflies
*Force (tefluthrin)		Caution	3	soil pests
*Mustang Max (zeta-cypermethrin)		Warning	3	beetles, caterpillars, leafhoppers, thrips
*Pounce (permethrin)		Caution - (3.2EC, 1.5G) Warning - (25WP, WSP)	3	beetles, caterpillars, leafhoppers, thrips
*Proaxis (gamma-cyhalothrin)		Caution	3	beetles, caterpillars, leafhoppers, plant bugs, stink bugs
Pyronyl Crop Spray (Pyrethrins)	contact, stomach, & fumigant action; extract from chyrsanthemums	Caution	3	broad spectrum
*Warrior (lambda-cyhalothrin)		Warning	3	beetles, caterpillars, leafhoppers, thrips
Other Insect Nerve Poisons				
Acramite-50WS (bifenazate)	contact action, not systemic	Caution	25	mites
*Agri-Mek (abamectin)	active once ingested; some contact action; mostly stomach poison	Warning	6	leafminers, mites, some beetles, tomato pinworm
Avaunt (indoxacarb)	ingestion plus contact, slightly to moderately translaminar	Caution	22	caterpillars
Fulfill (pymetrozine)	feeding inhibitor	Caution	9B	aphids, whiteflies
*Proclaim (emamectin benzoate)	ingestion & topical; translaminar, not systemic	Caution	6	caterpillars
SpinTor (spinosad)	ingestion & contact; enters leaf but does not translocate	Caution	5	caterpillars, some beetles and thrips
		Insect Growth Regulators		
Confirm (tebufenozide)	slow acting	Caution	18	caterpillars
Courier (buprofezin)	disrupts egg hatch and molting; use in rotation with other insecticides	Caution	16	whiteflies
*Dimilin (diflubenzuron)	slow acting, disrupts molting process, reduces egg hatch of pepper weevil	Caution	15	caterpillars, pepper weevil

Insecticide	General Characteristics	Signal Word	MOA[1]	Typical Target Pests
Esteem Ant Bait (pyriproxyfen)	breaks reproductive cycle of ants; slow acting but effective	Caution	7C	ants
Extinguish [(S)-methoprene]	slow acting	Caution	7A	fire ants
Intrepid (methoxyfenozide)	slow acting	Caution	18	caterpillars
Knack (pyriproxyfen)	use in combination or rotation with other insecticides	Caution	7C	whiteflies
Neemix (azadirachtin)	slow acting, also acts as feeding repellent	Caution - (Azatin XL Plus) Warning - (Neemix 4.5)	26	broad spectrum
Rimon (novaluron)	disrupts cuticle formation and deposition at molting, resulting in death of larva; no effect on adult insect	Warning	15	caterpillars
Trigard (cyromazine)	most effective against small leafminer larvae	Caution	17	dipterous leafminers, maggots, some beetles
Neonicotinyls				
Actara (thiamethoxam)	local systemic	Caution	4A	aphids, potato leafhopper, some beetles, stinkbugs, whiteflies
Admire (imidacloprid)	systemic, long residual	Caution	4A	aphids, leafhoppers, some beetles, whiteflies
Assail (acetamiprid)	local systemic, ovicidal effects	Caution	4A	aphids, Colorado potato beetle, whiteflies
Platinum (thiamethoxam)	systemic, long residual	Caution	4A	aphids, potato leafhopper, some beetles, stinkbugs, whiteflies
Provado (imidacloprid)	local systemic	Caution	4A	aphids, leafhoppers, some beetles, whiteflies
Venom (dinotefuran)	systemic or locally systemic, depending on application method, long residual	Caution	4A	aphids, Colorado potato beetle, leafhoppers, leafminers, thrips, whiteflies
Miscellaneous				
Bacillus thuringiensis (B.t.) var. *aizawai*	pest must ingest; slow acting but feeding stops long before death	Caution	11B1	caterpillars or beetles, depending on strain
Bacillus thuringiensis (B.t.) var. *kurstaki*	pest must ingest; slow acting but feeding stops long before death	Caution	11B2	caterpillars or beetles, depending on strain
Cryolite (Kryocide)	pest must ingest; not rainfast; an inorganic fluorine compound	Caution	9A	beetles, caterpillars
Mycotrol (Beauveria)	contact; slow acting		--	aphids, leafhoppers, whiteflies
Oberon (spiromesifen)	inhibitor of lipid synthesis; most effective on juvenile stages of mites and on nymphs and pupae of whiteflies and psyllids	Caution	23	mites, psyllids, whiteflies

Insecticide	General Characteristics	Signal Word	MOA[1]	Typical Target Pests
Oil (SunSpray Ultra Fine Spray Oil)	contact activity	Caution	--	aphids, mites, whiteflies
Soap (M-Pede)	contact activity; phytotoxic at high temperatures	Warning	--	aphids and other soft-bodied arthropods
*Vendex (fenbutatin-oxide)		Danger-Poison	12B	mites

*Restricted Use Pesticide

Originally adapted from: Welty, Celeste. Insecticides for use on vegetables in Ohio. pp. 46-48, 2002 Ohio Vegetable production Guide, Ohio State University.

[1] Mode of Action codes for vegetable pest insecticides from the Insecticide Resistance Action Committee (IRAC)

Mode of Action Classification v.3.3 October 2003.

1A. Acetylcholine esterase inhibitors, Carbamates

1B. Acetylcholine esterase inhibitors, Organophosphates

2A. GABA-gated chloride channel antagonists

3. Sodium channel modulators

4A. Nicotinic Acetylcholine receptor agonists/antagonists, Neonicotinoids

5. Nicotinic Acetylcholine receptor agonists (not group 4)

6. Chloride channel activators

7A. Juvenile hormone mimics, Juvenile hormone analogues

7C. Juvenile hormone mimics, Pyriproxifen

9A. Compounds of unknown or non-specific mode of action (selective feeding blockers), Cryolite

9B. Compounds of unknown or non-specific mode of action (selective feeding blockers), Pymetrozine

11B1. Microbial disruptors of insect midgut membranes, B.t. var aizawai

11B2. Microbial disruptors of insect midgut membranes, B.t. var kurstaki

12B. Inhibitors of oxidative phosphorylation, disruptors of ATP formation, Organotin miticide

15. Inhibitors of chitin biosynthesis, type 0, Lepidopteran

16. Inhibitors of chitin biosynthesis, type 1, Homopteran

17. Inhibitors of chitin biosynthesis, type 2, Dipteran

18. Ecdysone agonist/disruptor

20. Site II electron transport inhibitors

21. Site I electron transport inhibitors

22. Voltage-dependent sodium channel blocker

23. Inhibitors of lipid biosynthesis

25. Neuroactive (unknown mode of action)

26. Unknown mode of action, Azadirachtin

Weed Control in Tomato

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Although weed control has always been an important component of tomato production, its importance has increased with the introduction of the sweet potato whitefly and development of the associated irregular ripening problem. Increased incidence of several viral disorders of tomatoes also reinforces the need for good weed control. Common weeds, such as the difficult to control nightshade, and volunteer tomatoes (considered a weed in this context) are hosts to many tomato pests, including sweet potato whitefly, bacterial spot, and viruses. Control of these pests is often tied, at least in part, to control of weed hosts. Most growers concentrate on weed control in row middles; however, peripheral areas of the farm may be neglected. Weed hosts and pests may flourish in these areas and serve as reservoirs for re-infestation of tomatoes by various pests. Thus, it is important for growers to think in terms of weed management on all of the farm, not just the actual crop area.

Total farm weed management is more complex than row middle weed control because several different sites, and possible herbicide label restrictions are involved. Often weed species in row middles differ from those on the rest of the farm, and this might dictate different approaches. Sites other than row middles include roadways, fallow fields, equipment parking areas, well and pump areas, fence rows and associated perimeter areas, and ditches.

Disking is probably the least expensive weed control procedure for fallow fields. Where weed growth is mostly grasses, clean cultivation is not as important as in fields infested with nightshade and other disease and insect hosts. In the latter situation, weed growth should be kept to a minimum throughout the year. If cover crops are planted, they should be plants which do not serve as hosts for tomato diseases and insects. Some perimeter areas are easily disked, but berms and field ditches are not and some form of chemical weed control may have to be used on these areas. We are not advocating bare ground on the farm as this can lead to other serious problems, such as soil erosion and sand blasting of plants; however, where undesirable plants exist, some control should be practiced, if practical, and replacement of undesirable species with less troublesome ones, such as bahiagrass, might be worthwhile.

Certainly fence rows and areas around buildings and pumps should be kept weed-free, if for no other reason than safety. Herbicides can be applied in these situations, provided care is exercised to keep it from drifting onto the tomato crop. Field ditches as well as canals are a special consideration because many herbicides are not labeled for use on aquatic sites. Where herbicidal spray may contact water and be in close proximity to tomato plants, for all practical purposes, growers probably would be wise to use Diquat only. On canals where drift onto the crop is not a problem and weeds are more woody, Rodeo, a systemic herbicide, could be used. Other herbicide possibilities exist, as listed in Table 1. Growers are cautioned against using Arsenal on tomato farms as tomatoes are very sensitive to this herbicide. Particular caution should be exercised if Arsenal is used on seepage irrigated farms as it has been observed to move in some situations.

Use of rye as a windbreak has become a common practice in the spring; however, in some cases, adverse effects have resulted. If undesirable insects such as thrips buildup on the rye, contact herbicide can be applied to kill it and eliminate it as a host, yet the remaining stubble could continue serving as a windbreak.

The greatest row middle weed control problem confronting the tomato industry today is control of nightshade. Nightshade has developed varying levels of resistance to some post-emergent herbicides in different areas of the state. Best control with post-emergence (directed) contact herbicides are obtained when the nightshade is 4 to 6 inches tall, rapidly growing and not stressed. Two applications in about 50 gallons per acre using a good surfactant is usually necessary.

With post-directed contact herbicides, several studies have shown that gallonage above 60 gallons per acre will actually dilute the herbicides and therefore reduce efficacy. Good leaf coverage can be obtained with volumes of 50 gallons or less per acre. A good surfactant can do more to improve the wetting capability of a spray than can increasing the water volume. Many adjuvants are available commercially. Some adjuvants contain more active ingredient then others and herbicide labels may specify a minimum active ingredient rate for the adjuvant in the spray mix. Before selecting an adjuvant, refer to the herbicide label to determine the adjuvant specifications.

POSTHARVEST VINE DESSICATION

Additionally important is good field sanitation with regard to crop residue. Rapid and thorough destruction of tomato vines at the end of the season always has been promoted; however, this practice takes on new importance with the sweet potato whitefly. Good canopy penetration of pesticidal sprays is difficult with conventional hydraulic sprayers once the tomato plant develops a vigorous bush due to foliar interception of spray droplets. The sweet potato whitefly population on commercial farms was observed to begin a dramatic, rapid increase about the time of first harvest in the spring of 1989. This increase appears to continue until tomato vines are killed. It is believed this increase is due, in part, to coverage and penetration. Thus, it would be wise for growers to continue spraying for whiteflies until the crop is destroyed and to destroy the crop as soon as possible with the fastest means available. Both diquat and paraquat are now labeled for postharvest dessication of tomato vines. The labels differ slightly so it's important to follow the label directions.

The importance of rapid vine destruction can not be overstressed. Merely turning off the irrigation and allowing the crop to die is not sufficient; application of a desiccant followed by burning is the prudent course.

Herbicide	Labeled Crops	Time of Application to Crop	Rate (lbs. AI./Acre)	
			Mineral	Muck
Carfentrazone (Aim)	Fruiting Vegetables Tomato	Directed-hooded row-middles	0.008-0.025	0.008-0.025
Remarks: Aim may be applied as a post-directed hooded burn-down application to emerged broadleaf weeds in row middles. Aim is not labeled for grassy weeds. May be tank mixed with other herbicides registered for this treatment pattern. May be applied at 0.33 oz (0.008 lb ai) to 1 oz (0.025 lb ai). Use a quality spray adjuvant such as crop oil concentrate (coc) or non-ionic surfactant (nis) at recommended rates.				
Clethodim (Select 2 EC)	Tomatoes	Postemergence	0.9-.125	---
Remarks: Postemergence control of actively growing annual grasses. Apply at 6-8 fl oz/acre. Use high rate under heavy grass pressure and/or when grasses are at maximum height. Always use a crop oil concentrate at 1% v/v in the finished spray volume. Do not apply within 20 days of tomato harvest.				
DCPA (Dacthal W-75)	Established Tomatoes	Posttransplanting after crop establishment (non-mulched)	6.0-8.0	---
Remarks: Controls germinating annuals. Apply to weed-free soil 6 to 8 weeks after crop is established and growing rapidly or to moist soil in row middles after crop establishment. Note label precautions of replanting non-registered crops within 8 months.				
Diquat (Reglone)	Tomato Vine Burndown	After final harvest	0.375	---
Remarks: Special Local Needs (24c) label for use for burndown of tomato vines after final harvest. Applications of 1.5 pts. material per acre in 60 to 120 gals. of water is labeled. Add 16 to 32 oz. of Valent X-77 spreader per 100 gals. of spray mix. Thorough coverage of vines is required to insure maximum burndown.				
Diquat dibromide (Reglone)	Tomato	Pretransplant Postemergence directed-shielded in row middles	0.5	---
Remarks: Diquat can be applied as a post-directed application to row middles either prior to transplanting or as a post-directed hooded spray application to row middles when transplants are well established. Apply 1 qt of Diquat in 20-50 gallons of water per treated acre when weeds are 2-4 inches in height. Do not exceed 25 psi spray pressure. A maximum of 2 applications can be made during the growing season. Add 2 pts non-ionic surfactant per 100 gals spray mix. Diquat will be inactivated if muddy or dirty water is used in spray mix. A 30 day PHI is in effect. Label is a special local needs label for Florida only.				
Halosulfuron (Sandea)	Tomatoes	Pre-transplant Postemergtence Row middles	0.024 - 0.036	---
Remarks: A total of 2 applications of Sandea may be applied as either one pre-transplant soil surface treatment at 0.5-0.75 oz. product; one over-the-top application 14 days after transplanting at 0.5-0.75 oz. product; and/or postemergence applications(s) of up to 1 oz. product (0.047 lb ai) to row middles. A 30-day PHI will be observed. For postemergence and row middle applications, a surfactant should be added to the spray mix.				
MCDS (Enquik)	Tomatoes	Postemergence directed/ shielded in row middle	5 - 8 gals.	---
Remarks: Controls many emerged broadleaf weeds. Weak on grasses. Apply 5 to 8 gallons of Enquik in 20 to 50 gallons of total spray volume per treated acre. A non-ionic surfactant should be added at 1 to 2 pints per 100 gallons. Enquik is severely corrosive to nylon. Non-nylon plastic and 316-L stainless steel are recommended for application equipment. Read the precautionary statements before use. Follow all restrictions on the label.				
S-Metolachlor (Dual Magnum)	Tomatoes	Pretransplant Row middles	1.0 - 1.3	---
Remarks: Apply Dual Magnum preplant non-incorporated to the top of a pressed bed as the last step prior to laying plastic. May also be used to treat row-middles. Label rates are 1.0-1.33 pts/A if organic matter is less than 3%. Research has shown that the 1.33 pt may be too high in some Florida soils except in row middles. Good results have been seen at 0.6 pts to 1.0 pints especially in tank mix situations under mulch. Use on a trial basis.				

Herbicide	Labeled Crops	Time of Application to Crop	Rate (lbs. AI./Acre) Mineral	Muck
Metribuzin (Sencor DF) (Sencor 4)	Tomatoes	Postemergence Posttransplanting after establishment	0.25 - 0.5	---
Remarks: Controls small emerged weeds after transplants are established direct-seeded plants reach 5 to 6 true leaf stage. Apply in single or multiple applications with a minimum of 14 days between treatments and a maximum of 1.0 lb ai/acre within a crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury.				
Metribuzin (Sencor DF) (Sencor 4)	Tomatoes	Directed spray in row middles	0.25 - 1.0	---
Remarks: Apply in single or multiple applications with a minimum of 14 days between treatments and maximum of 1.0 lb ai/acre within crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury. Label states control of many annual grasses and broadleaf weeds including, lambsquarter, fall panicum, amaranthus sp., Florida pusley, common ragweed, sicklepod, and spotted spurge.				
Napropamid (Devrinol 50DF)	Tomatoes	Preplant incorporated	1.0 - 2.0	---
Remarks: Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 1 to 2 inches. Incorporate same day as applied. For direct-seeded or transplanted tomatoes.				
Napropamid (Devrinol 50DF)	Tomatoes	Surface treatment	2.0	---
Remarks: Controls germinating annuals. Apply to bed tops after bedding but before plastic application. Rainfall or overhead-irrigate sufficient to wet soil 1 inch in depth should follow treatment within 24 hours. May be applied to row middles between mulched beds. A special Local Needs 24(c) Label for Florida. Label states control of weeds including Texas panicum, pigweed, purslane, Florida pusley, and signalgrass.				
Oxyfluorfen (Goal 2XL)	Tomatoes	Fallow bed	0.25 - 0.5	
Remarks: Must have a 30 day treatment-planting interval. Apply as a preemergence broadcast or banded treatment at 1-2 pt/A to preformed beds. Mulch may be applied any time during the 30-day interval.				
Paraquat (Gramoxone Extra) (Gramoxone Max)	Tomatoes	Premergence; Pretransplant	0.62 - 0.94	---
Remarks: Controls emerged weeds. Use a non-ionic spreader and thoroughly wet weed foliage.				
Paraquat (Gramoxone Extra) (Gramoxone Max)	Tomatoes	Post directed spray in row middle	0.47	---
Remarks: Controls emerged weeds. Direct spray over emerged weeds 1 to 6 inches tall in row middles between mulched beds. Use a non-ionic spreader. Use low pressure and shields to control drift. Do not apply more than 3 times per season.				
Paraquat (Gramoxone Extra) (Gramoxone Extra)	Tomato	Postharvest dessication	0.62-0.93	0.46-0.62
Remarks: Broadcast spry over the top of plants after last harvest. Label for Boa states use of 1.5-2.0 pts while Gramoxone label is from 2-3 pts. Use a nonionic surfactant at 1 pt/100 gals to 1 qt/100 gals spray solution. Thorough coverage is required to ensure maximum herbicide burndown. Do not use treated crop for human or animal consumption.				
Pelargonic Acid (Scythe)	Fruiting Vegetable (tomato)	Preplant Preemergence Directed-Shielded	3-10% v/v	---
Remarks: Product is a contact, nonselective, foliar applied herbicide. There is no residual control. May be tank mixed with several soil residual compounds. Consult the label for rates. Has a greenhouse and growth structure label.				

Herbicide	Labeled Crops	Time of Application to Crop	Rate (lbs. AI./Acre) Mineral	Muck
Rimsulfuron (Matrix)	Tomato	Posttransplant and directed-row middles	0.25 - 0.5 oz.	---
Remarks: Matrix may be applied preemergence (seeded), postemergence, posttransplant and applied directed to row middles. May be applied at 1-2 oz. product (0.25-0.5 oz ai) in single or sequential applications. A maximum of 4 oz. product per acre per year may be applied. For post (weed) applications, use a non-ionic surfactant at a rate of 0.25% v/v. for preemergence (weed) control, Matrix must be activated in the soil with sprinkler irrigation or rainfall. Check crop rotational guidelines on label.				
Sethoxydim (Poast)	Tomatoes	Postemergence	0.188 - 0.28	---
Remarks:: Controls actively growing grass weeds. A total of 42 pts. product per acre may be applied in one season. Do not apply within 20 days of harvest. Apply in 5 to 20 gallons of water adding 2 pts. of oil concentrate per acre. Unsatisfactory results may occur if applied to grasses under stress. Use 0.188 lb ai (1 pt.) to seedling grasses and up to 0.28 lb ai (12 pts.) to perennial grasses emerging from rhizomes etc. Consult label for grass species and growth stage for best control.				
Trifloxysulfuron (Envoke)	Tomatoes (transplanted)	Post directed	0.007-0.014	
Remarks: Envoke can be applied at 0.1 to 0.2 oz product/A post-directed to transplanted tomatoes for control of nutsedge, morningglory, pigweeds and other weeds listed on the label. Applications should be made prior to fruit set and at least45 days prior to harvest. A non-ionic surfactant should be added to the spray mix.				
Trifluralin (Treflan HFP) (Treflan TR-10) (Trilin) (Trilin 10G) (Trifluralin 480) (Trifluralin 4EC) (Trifluralin HF)	Tomatoes (except Dade County)	Pretransplant incorporated	0.5	---
Remarks: Controls germinating annuals. Incorporate 4 inches or less within 8 hours of application. Results in Florida are erratic on soils with low organic matter and clay contents. Note label precautions of planting non-registered crops within 5 months. Do not apply after transplanting.				
Trifluralin (Treflan HFP) (Treflan TR-10) (Trilin) (Trilin 10G) (Trifluralin 480) (Trifluralin 4EC) (Trifluralin HF)	Direct-Seeded tomatoes (except Dade County)	Post directed	0.5	---
Remarks: For direct-seeded tomatoes, apply at blocking or thinning as a directed spray to the soil between the rows and incorporate.				

Nematicides Registered for Use on Florida Tomato

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Product	Row Application (6' row spacing - 36'' bed)[4] Broadcast (Rate)	Recommended Chisel Spacing	Chisels (per Row)	Rate/Acre	Rate/1000 Ft/Chisel
FUMIGANT NEMATICIDES					
Methyl Bromide[3] 67-33	225-375 lb	12''	3	112-187 lbs	5.1 - 8.6 lb
Chloropicrin[1]	300-500 lb	12''	3	150-250 lbs	6.9 - 11.5 lb
Telone II[2]	9-12 gal	12''	3	4.5-9.0 gal	26 - 53 fl oz
Telone C-17	10.8-17.1 gal	12''	3	5.4-8.5 gal	31.8-50.2 fl oz
Telone C-35	13- 20.5 gal	12''	3	6.5-13 gal	22-45.4 fl oz
Metham Sodium	50-75 gal	5''	6	25 - 37.5 gal	56 - 111 fl oz
NON-FUMIGANT NEMATICIDES					
Vydate L - treat soil before or at planting with any other appropriate nematicide or a Vydate transplant water drench followed by Vydate foliar sprays at 7-14 day intervals through the season; do not apply within 7 days of harvest; refer to directions in appropriate "state labels", which must be in the hand of the user when applying pesticides under state registrations.					

[1] If treated area is tarped, dosage may be reduced by 33%.

[2] The manufacturer of Telone II, Telone C-17, and Telone C-35 has restricted use only on soils that have a relatively shallow hard pan or soil layer restrictive to downward water movement (such as a spodic horizon) within six feet of the ground surface and are capable of supporting seepage irrigation regardless of irrigation method employed. Higher label application rates are possible for fields with cyst-forming nematodes. Consult manufacturers label for personal protective equipment and other use restrictions which might apply.

[3] Use of methyl bromide for agricultural soil fumigation in tomato now officially occurs during the period Jan 1, 2005 to Jan 1, 2006 via international approval of a specific Florida request for a Critical Use Exemptions (CUE). Consult your local University of Florida Cooperative Extension Service county office for additional information regarding official approved uses, soil application rates, and state and federal reporting requirements.

[4] Rate/acre estimated for row treatments to help determine the approximate amounts of chemical needed per acre of field. If rows are closer, more chemical will be needed per acre; if wider, less.

Rates are believed to be correct for products listed when applied to mineral soils. Higher rates may be required for muck (organic) soils. Growers have the final responsibility to guarantee that each product is used in a manner consistent with the label. The information was compiled by the author as of July 14, 2005 as a reference for the commercial Florida tomato grower. The mention of a chemical or proprietary product in this publication does not constitute a written recommendation or an endorsement for its use by the University of Florida, Institute of Food and Agricultural Sciences, and does not imply its approval to the exclusion of other products that may be suitable. Products mentioned in this publication are subject to changing Environmental Protection Agency (EPA) rules, regulations, and restrictions. Additional products may become available or approved for use.